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THE WAY OF THE SILPIS

or

Hindu approach to Art and Science

BY

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Dedicated

To the loving memory of

ITULIE OF ETATHANAT

My Mother's mother

To whose loving care I owed my life

from the very day of my birth.

G. K. PILLAI

PREFACE

A benign Government, forced a period of Medical leave on me. Late Sir C. Y. Chintamani placed a copy of 'Manasara Silpa-Sastra' at my disposal. Certain discrepancies in the book made me to investigate. Satisfactory solutions encouraged me to further investigation and research. This book is the result of my investigation lasting over a period of several years, through a period of busy professional life as an Engineer. My investigation and research are not complete. It is hoped that others may take up the subject and present a true appreciation of Indian culture.

My thanks are due to the Archeological Department, Government of India, and the Municipal Board, Allahabad for giving me permission to insert some of their Pictures in the book.

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18-A, Queens Road,
Allahabad.

G. K. PILLAI

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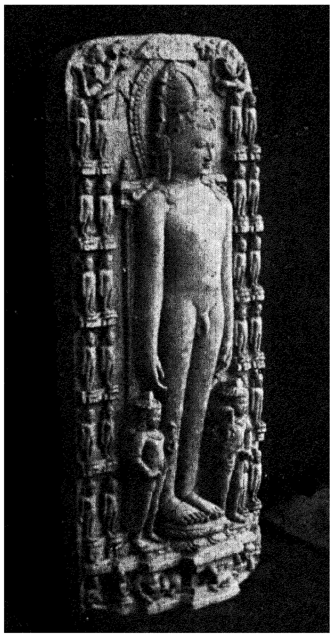


"The Prince" from Manbhum.

THE WAY OF THE SILPIS

CHAPTER I

Introductory

IN DAYS GONE BY WHEN THERE WAS NO DIFFFRENCE BETWEEN Art and Craft, and the artists and craftsmen were the same, the Hindus used the term " SILPI " to designate the artist, architect and sculptor, whose activities extended to the sciences, such as mathematics and astronomy. Hence " The way of the Silpis " means the Hindu approach to the Art and Science.

It is generally admitted now that the Hindus in ancient times had acquired a high standard of proficiency in Art, Architecture and Mathematics. To judge the exact extent of their attainment has become practically impossible owing to (i) the scarcity of accurate records, (ii) waning traditions, and (iii) introduction of religion and superstition in purely scientific matters. There are, however, a good many books and traditions from which, if the garbage is removed, facts can be collected in a remarkable degree.

The chief sources of information are the Silpa-Sastras, Puranas and Agamas. The Silpa-Sastras are treatises on Architecture and Sculpture; the Puranas and Agamas contain ancient practices, both religious and secular. The Silpa-Sastras must originally have been written by the Silpis or the Architects; but the books, that are now available, bear more the stamp of transcribers than that of masters well versed in the art. Hence errors of omission and commission and loose or incorrect renderings are common rather than rare.

The Puranas deal with many a subject in the purview of one volume. Agni Purana, for instance, one of the best known of them, deals with Law and Order, War and Defence, Astronomy and Astrology, Diplomacy and Monarchy, Herbs and Medicine, Geography and Physiography, Religion and Witchcraft, Penance and Discipline, Fortune-telling and Dreams, Architecture and Sculpture, among the rest. It would have been hardly possible for any one individual to be proficient in all these. The writers appear to have realised this truth ; hence they attributed all the Puranas to divine beings or Gods.

The Agamas, like the Puranas, are encyclopædic works, dealing with heterogeneous subjects. The twenty-eight chief Agamas, like the eighteen Puranas, deal incidentally with Architecture and Sculpture. What the Puranas are to North India, the Agamas are to South India.

The origin of the Silpa-Sastra is attributed to Siva, the Great Architect of the Universe. Every knowledge is supposed to have been given out by the gods to particularly chosen individuals of a semi-divine character, who in their turn handed it down to posterity through chosen disciples. Consequently the inventor and the author are both lost in oblivion. This practice is not in any way peculiar to the Hindus ; every religion tells the same story ; and every tradition repeats it. Even the ancient Greeks attributed to Pythagoras all mathematical discoveries, even those that were made after his death. In India priceless discoveries, like the Zero and the place-value notation, are anonymous ; nevertheless they are there, and have helped the world to make gigantic strides in mathematics centuries afterwards.

In an age when literacy was limited, knowledge was in the

custody of a privileged few, and script and spoken language underwent constant changes, it is but natural that records should become few and inaccuracies creep in even into those that were kept. When the antiquity of the discoveries and the inauguration of the practices are judged by the lapse of time and by the changes taken place in the country, it is surprising what a great volume of information has come down to us, though often distorted and garbled into religion and superstition. In sifting the truth out from the Puranas and Sastras, one is naturally inclined to be influenced by prejudices and pre-conceived notions which are easy for no one to discard. However a sympathetic consideration and broad out-look will serve to discern the facts and to present them in their true perspective.

The Silpi practices and rules should be considered as dating back from the beginning of Indian Civilization, provided they were not borrowed from other nations. In judging the beginning of Indian Civilization, the Rig-Veda used to be the determining factor ; but since the discovery of the ruins of Mohenjo-daro and Harappa, the beginning of Indian Culture should naturally be pushed back beyond 3,250 B.C. Greek Mathematics had its origin in Asiatic Anatolia about the middle of the sixth century B.C., practically at the same time that Buddhism made its appearance in India. The well-known civilizations, prior to this, were those of Egypt and Chaldea. The Egyptian civilization dates back to the fifty-ninth century B.C., while that of Chaldea, according to some, may be earlier still. Whether these civilizations had any influence on Indian culture, or the ancient Hindus mapped out a line of their own, is a controversy which may become acute in years to come, when more Mohenjo-daros, the cities of the dead, are brought to light by the spade of the Archeologists

in the plains and tablelands of India. Mathematical investigation, however, may reveal a close resemblance between the ancient Hindu and the Egyptian practices.

The value of π, or the relation between the circumference and the diameter of a circle, used to exercise the imagination of thinkers in all countries ; consistent attempts at squaring the circle were given up in Europe only within the last two centuries. The Egyptian value of π, according to the Rynd Papyrus, a document written in the earlier part of the nineteenth century B.C., is $(16/9)^2$. It is surprising to see that it is the only convenient value of π that can be used in circling a square, to construct Vedic Altars. The trapezium, which forms another famous altar of the Hindus, bears a close resemblance to a trapezium given in the Rynd Papyrus. If the facts are such, are these mere coincidences ? Or do they show the influence of one culture on another ? Is it likely that the Hindus, most orthodox as they were, borrowed the secret of their religious rites from the Egyptians ? Or did the Egyptians, who constructed the Pyramids, get a workable value of π from the Hindus or the Dravidians of Mohenjo-daro fame ?

It is stated even by some of the most distinguished scholars that Geometry became essential to the Hindus on account of their sacrificial rites. This, it seems to me, is putting the cart before the horse. Most probably the regular construction of the sacrificial altars originated in their desire to keep geometrical truths alive ; the aborigines, like the Orans and Mundas, do the sacrifices without much Geometry about their altars. If the Pharaohs have built Pyramids to perpetuate astronomical and mathematical facts, and if the Druids built Stonehenge for a similar purpose, why should the Hindus not have elaborated their altars to perpetuate geometrical principles ? In judging

the ancients, if one could transport himself to their surroundings, most of the inexplicable might become explicable.

The Silpa-Sastras are many. In Manushyalaya-chandrika, a later treatise on Silpa-sastra, found on the Malabar coast, the author, Tirumangalathu Nila-Kantan Mutsu states that he consulted several standard works on the subject, before he commenced his book. The books, he consulted, were :—

Maya-Mata—(2 Volumes), Prayoga-manjari, Nibandhanas, Bhaskarieyam—(2 Volumes), Manu-mata, Gurupadhathi, Markandeya—(2 Versions), Parasara Ratnavali, Murari Ratnavali, Kasyapamata, Visvakarmamata, Kumara-agama, Vastu-vidya, Thantra-samuchaya.

The exact date of the Manushyalaya-chandrika is not known; the book, however, is not very ancient, may not be more than three centuries old. Most of the names, associated with these books, are house hold names even now, namely, Maya, Viswa-karma, Parasara, Kashyapa and Manu, though they lived centuries before Christ. Maya appears to be the most ancient of these; his time cannot be determined, but decidedly he was a Dravidian. The latest of these appears to be Manu; but this Manu should not be confused with the King Manu, the progenitor of the Ikshvaku kings of Ayodhya. Manu, the author of the Manu-Mata, is most probably the Law-giver Manu; and as such, he must have lived about the eighth century B.C. Parasara's time can be determined in relation to the date of the great Mahabharata war. The date of the Mahabharata war, according to Professor Radha Kumud Mukherji, is about 1,400 B.C.; but Justice Pargitter's more conservative computation fixes it at 950 B.C. Parasara lived two generations before the Mahabharata war. Therefore, it can safely be stated that Parasara's time was about 1,000 B.C. The Bhas-

kara, connected with the Bhaskariem, may be one of the two Bhaskaras. If it is Bhaskara II, he appears to have lived about 1150 A.D. It should be noticed that Nilakantan Mutsu, the author of the Manushyalaya-chandrika, does not mention the Manasara-Silpa Sastra, the monumental translation of which by Dr. P. K. Acharya has given us an entirely new out-look on the much discredited architecture of the Hindus. Probably, Manasara was not known in the south. There are three books, associated with the names of Visva Karma, namely, Vastu-karma, Vastu-Sastra and Prakasa. He should not be mistaken for the Visva-karma, the great Architect of the Universe. Kasyapamata is attributed to the sage Kasyapa, who is considered a great authority, particularly by the Silpis of South India ; and he is reputed to be the progenitor or preceptor of the Tamil Brahmins of the Kasyapa gotra (or clan). Many Bengalees also consider him as their preceptor. The last two books, mentioned in the list, Vastu-vidya and Thantra-samuchaya, are both well known and commonly used by the Silpis on the Malabar coast.

No doubt, some books of Silpa-sastra, like Maya-mata, have their origin in the hoary past, but that is no excuse for giving the entire works such great antiquity as is given by some scholars. If the construction of a Buddhist temple is mentioned in any book, as it is done in Manasara, it is certain that at least that part of the book was written at a date later than that of Buddha. However, from the rituals and ceremonies associated with the lay-out and construction of buildings, it will be seen that the Silpa-sastras attained their maturity at a time, when it was the general habit of the people to eat meat and drink wine, which has not been the general custom since the revival of Hinduism, after the Buddhist period. At every stage of construction, the

sacrifice of animals and dedication of wine or spirits are ordained by the Sastras. If people were non-meat eaters and teetotallers at that time, this would not have happened. Indians were great meat-eaters until the time of Asoka. His reign began about 263 B. C., and from his edicts it will be seen that he discouraged meat-eating. So it can be assumed that the Silpa-sastras took their formal shape, at any rate, before this period.

At present, those, who practice the Silpa-sastra generally, are not caste Hindus ; especially in the South, they belong to the so-called untouchables. Yet at the time of the rituals and ceremony they don the sacred thread and perform "Pujas" (sacred rites),- indicative of the fact that their ancestors at any rate were "Dwijas" or men of rank and position. It is this class of Silpis, who nurtured and maintained the Silpa-sastras and handed them down to posterity. Unfortunately, the Silpis seem to have done little in the way of writing; even if they did any, we have not the benefit of it. The few books, that are available, seem to have been written by non-silpis ; their authors certainly were learned men, and we owe them a deep debt of gratitude for preserving the traditions of the past. They have collected whatever information available to them ; some of them have put the materials down in the excellent language and form of those days which, unfortunately by custom and convention, had to be verse. Metre and rime made it easier for the scholar to commit the works to memory, but the works lack the lucidity of prose and the direct approach to the subject matter, which can be achieved effectively only in prose. What was written in verse was capable of different interpretations ; and in a language like Sanskrit, which has got an extraordinary number of meanings for words and phrases, each scholar was liable to give his own interpretation. What we find in later works are

these interpretations. If the authors were Silpis or technical men, who carried out design and construction themselves, a great deal of doubts and uncertainties would have been avoided. The major portion of the work suffers the fate of Surgical treatise written by a physician.

Another kind of error, that has crept into the texts, is due to transcription. Copies of the texts were made by handwriting; any omission or inclusion, wittingly or unwittingly done by the transcriber, made a great deal of difference in the copies. There is a saying in Sanskrit that the word "Muhurta", thrice transcribed, turns into "Mutra". Muhurta means an auspicious moment, while Mutra means urine. This is no exaggeration. In spite of all this, the information, that has come down to us, is sufficient to enable us to gauge the attainment of the ancient Indians in this respect.

Detailed specifications and conditions of contract are the means at the present time to ensure standard and efficiency in construction. The conditions of contract are often harsh on the contractors. Though strict adherence to the specifications can be enforced by law, every man, in charge of constructions, knows how difficult they are to apply without retarding the progress of the work, or without incurring the displeasure of his employer. In ancient days, they seem to have overcome this difficulty, in an ingenious way, by putting the fear of God into all concerned. In medieval times, the quality of workmanship and soundness of construction used to be ensured by imposition of capital punishment or mutilation of limbs; but the ancient Silpis made people believe that non-adherence to the specification or a violation of the tradition would lead one to dire consequences, such as damage or loss to person and property according to the serious-

ness of the offence; further, to those undaunted by this to be careful, held out the fear of the same consequences to their sons and grandsons as well. The persons, for whom the buildings were constructed, were also not left out; if they did not see that correct procedure was followed, they and their successors also were to meet the ire of the gods. This kind of fear induced in ancient days is a living force; the fear, driven into the mind of the people by centuries of usage, still exists. Sometime ago, a high Government official, in Simla, told me, how the silpis or carpenters, engaged by him to make certain additions to his ancestral house in Malabar, consistently refused his instructions notwithstanding the risk of losing his patronage. Why! It was only the other day in the town of Asansol (Bengal), a mason threatened to leave the job rather than place a kitchen door against his traditional practice. The mason could not give any reason for his refusal. Instances, similar to these, are many, and they clearly indicate that the Silpi ways are still in the country, though they are submerged and inarticulate.

Why should we, in these days of advancement in art and science, give any heed to what the silpis did thousands of years ago? Similar questions may be asked about the study of ancient history, anthropolagy, and classical languages. Whatever contribution has been made by our ancestors towards human progress, cannot but have its influence on our present state and future development. The Silpis appear to have been pioneers in the fields of art and science; their contribution stands high in the fields of mathematics and astronomy; in art and acrhitecture too, though our taste may differ from theirs, they made gigantic strides, and made every attempt to reduce them to sciences. Their attempt to do so is what is proclaimed on every page of the Silpa-

sastras. The study of the Silpa-sastras or the ways of the Silpis cannot but be of interest to those who study art and architecture. "To study a subject properly", says Sir Thomas Heath, "we must study it as something that is alive and growing and consider it with reference to its origin and its evolution in the past." A proper study of the Silpi methods, which appear to have had an independent origin, will not only enable us to trace the origin and development of Indian culture in its true perspective, but also confront us with certain ideas and principles, which will be of interest to laymen and experts alike. Further no knowledge of India is complete without knowing the ways of the Silpis.

THE WAY OF THE SILPIS

CHAPTER II

Determination of the Cardinal Points

IN SULVA-SASTRAS, ANCIENT TEXTS ON THE CONSTRUCTION OF Sacrificial altars, no directions are given to find the cardinal points, though it was essential that the Altars were to be constructed with true orientation. Some deplore this as a serious omission. If it is realized that Sulvas are complementary to Silpa-Sastras, the question of omission does not arise. In Silpa-sastras, great stress is laid on the determination of the East-West line. Among the ancient Greeks, the straight line was an array of points in an absolute space. The Indians have always conceived a line as having a direction, and seem to have forestalled the fundamental idea behind the co-ordinate Geometry, later on expounded in Europe by the Mathematicians of the 18th Century.

The Ancient Egyptians determined the North point first, but the Silpis of India determined the East-West line first. Both used the Sun's shadow for the purpose. The Egyptians errected a tall obelisk for casting the shadow, while the Hindus used a small gnomon or peg. The Egyptians determined the meredian from the Sun's shadow when it was shortest, but the Hindus determined the east-west line from long shadows when they touched a circle.

The setting up of a gnomon, for shadow reckoning, is known in Silpasastras as the erection of the Sank. The Sank is actually a sea shell used for producing a blasting sound at religious ceremonies and call for battle. This is not the original Sank used by the Silpis for casting shadow, as it is not quite suitable for the

purpose. There is a kind of gazelle-horn, which is also called Sank and used for producing blasting sounds in connection with witchcraft. It has a curvilenial fluted surface tapering to a suitable point at one end; a fairly straight one of the kind appears to have been the first gnomon they used. The later types of the gnomons are made of hard and well-seasoned wood and sometimes even of ivory. It is generally about nine inches long, an inch and a half in diameter at the bottom, tapering uniformly to three-quarters of an inch at the top and ending in the shape of a lotus bud at the end. In Mansara, the gnomons are specified even to eighteen inches in length.

The gnomon is to be set up on a plot of ground about six feet square, well consolidated, levelled and smoothed over. In the centre of the plot a circle is drawn with a radius equal to twice the length of the gnomon; at the centre of the circle the gnomon is placed in a truly vertical position. It is to be set up in the morning and the shadow cast by it is to be carefully watched. See diagram (1) when the tip of the shadow touches the circumference of the circle, in the western half, that point is to be marked, and let this be W in the Diagram (1). In the afternoon when the shadow falls on the eastern half of the circle, another point is marked on the circumference, say point E. Generally speaking, the line, drawn between these two points, should give the east west direction. But the true east-west direction is somewhat different from this, due to the precessional variation, or the variation in consequence of the declination of the Sun during the interval between the two observations, one in the forenoon and the other in the afternoon. To find, therefore, the true east and west, some correction to the direction of the line EW is required.

In Manasara Silpa-sastra, the correction of the shadows for each month, nay for each ten days of the month, is given as in Table I.

TABLE I.—Shadow correction figures.

English Months.	Hindu Months.	Period.	Correction figures in angulars.
1. July—August.	Simha.	1st. 10 days.	2.
		2nd. ,, ,,	1.
		3rd. 10 days	0.
2. August—September.	Kanya.	1st. ,, ,,	0.
		2nd. ,, ,,	1.
		3rd. ,, ,,	2.
3. September—October.	Tula.	1st. ,, ,,	2.
		2nd. ,, ,,	3.
		3rd. ,, ,,	4.
4. October—November.	Vrischika.	1st. ,, ,,	4.
		2nd. ,, ,,	5.
		3rd. ,, ,,	6.
5. November—December.	Dhanus.	1st. ,, ,,	6.
		2nd. ,, ,,	7.
		3rd. ,, ,,	8.
6. December—January.	Makara.	1st. ,, ,,	8.
		2nd. ,, ,,	7.
		3rd. ,, ,,	6.
7. January—February.	Kumbha.	1st. ,, ,,	6.
		2nd. ,, ,,	5.
		3rd. ,, ,,	4.
8. February—March.	Mina.	1st. ,, ,,	4.
		2nd. ,, ,,	3.
		3rd. ,, ,,	2.
9. March—April.	Mesha.	1st. ,, ,,	2.
		2nd. ,, ,,	1.
		3rd. ,, ,,	0.
10. April—May.	Vrishabha.	1st. ,, ,,	0.
		2nd. ,, ,,	1.
		3rd. ,, ,,	2.
11. May—June	Mithuna.	1st. ,, ,,	2.
		2nd. ,, ,,	3.
		3rd. ,, ,,	4.
12. June—July.	Karkataka.	1st. ,, ,,	4.
		2nd. ,, ,,	3.
		3rd. ,, ,,	2.

One Angula is equal to three-quarters of an English Inch. These correction figures are considered to be too high, or the units, in which these are given, are considered by P. K. Acharya too big. Are they too big? From a close analysis of the text, it will become clear that the units, intended to be used for correction, are the same as those by which the gnomon is to be measured. The text (*Manasara*, Chapter VI, verses 29-30) reads thus:—"The length of the gnomon being divided into ninty-six parts, and the Apachhaya being left out of these parts, the due east should then be determined." Apachhaya ordinarily means penumbra, but here it should mean the shadow which is deviated or displaced, which appears to have been its original meaning, probably before Panini's Grammar was written. Certainly Apachhaya cannot be deducted from the gnomon or peg. It can be deducted only from a chhaya or shadow. Therefore, the gnomon in the context stands for the shadow. The shadows under consideration are two, the west and the east shadows, the one marked in the morning and the other marked in the afternoon, such as those given by the points W and E in Diagram (I) or B and A′ in Diagram (2). The combined length of these shadows is BO+OA′. The length of the gnomon, according to Manasara, Chapter VI, Verses 13-14, should be one cubit, that is 24 Angulas (18 English Inches). The radius of the gnomon circle is twice the length of the gnomon. Therefore, the length of the shadows BO+OA′ is equal to 96 Angulas. It is evident that it is these 96 angula divisions of the gnomon that are referred to in the text. The term gnomon may mean the peg, or the shadow, or the peg shadow and the circle, all combined. If this argument is accepted, then the next point is how and where the correction is to be made.

For this, verses 36-37, Chapter VI of Manasara are to be analysed. The verses read thus :—"The aforesaid Angulas (the correction Angulas) should be marked in the shadow to the left and right of the Bindu (or the centre); with what is left of these Angulas the due East line should be drawn." For a correct interpretation of these verses, a clear conception of the behaviour of the shadow is essential. This may be seen from Diagram (3) which shows the result of some observations taken at Allahabad.

The points of the shadow on the circumference of the circle change from day to day. They oscilliate backward and forward on the circumference. If continuous observations are made for each day, it will also be seen that the tip of the shadow makes a continuous curve across the circle, during the transit of the shadow from west to east. These curves are concave or convex with reference to the centre of the circle, except that they are straight on certain days of the year. But these curves of straight lines always fall on the north side of the peg, and never on the south side of it. The straight lines are formed by the change of the curve from concave to convex, or from convex to concave. If the shadows can be got on those days when the transit curves are straight lines, no correction due to the declination of the shadow is required, and the straight line obtained will indicate the true east-west direction.

This fact is still known and taken advantage of in some parts of India. To avoid the necessity of shadow-correction the Silpis of Malabar coast, orientate their buildings on these days. The straight line transit of the shadow indicates the zero correction, or the neutral position. As the shadow moves from the neutral position, either north or south, the declination increases, and the correction has to be made according to the declination. Two

maximum declinations take place, at the extreme positions, one in the north and the other in the south of the neutral position, and the maximum in the north is greater than the maximum in the south. When the shadow moves from the extreme positions from the north or south, towards the neutral position, the declination decreases. The extreme position at the north, with the maximum declination is the Winter Solstice, and the extreme position at the south of the neutral, with the maximum declination is the Summer Solstice. Hence Manasara states—"During the six months beginning with Makara (December-January) the shadow declines towards the south, and during the six months beginning with Kulira or Karkata (June-July) the shadow declines towards the north."

Thus it will be seen that the gradation of the correction figures, given by Manasara, is quite in confirmity with the ambulations of the shadow, from zero it increases to four, then it decreases to zero; then again it increases to eight and decreases to zero. But the manner, in which the correction has to be applied according to Manasara, is not clear. However, it is evident from the text that the corrections are to be applied at the left and the right of the centre, thereby indicating that some corrections are to be made at the right, and some at the left of the Bindu or centre. The right and the left have no significance whatsoever looking at the shadow from an east-westerly direction, for, all the shadows fall on one side, namely, the north of the gnomon. It is, therefore, certain that the right and the left, referred to in the text, pertain to a direction north-south. Now there are shadows on the right and left of the North-South direction or the east and west of the gnomon, one shadow recorded in the morning and the other one recorded in the afternoon. Perhaps the terms, east and west,

were not used by them as they wished to avoid confusion: and right and left may have had their origin with reference to the observer, who would naturally take up his place on the North, to avoid his own shadow falling on the gnomon, or overturning the gnomon in the act of recording the shadows. The shadow, that falls on the right of the observer, is the morning shadow; and the one, that falls on the left, is the evening shadow.

Referring to the Diagram (2), let the line NM represent the true east and west line on a day in which no Apachhaya correction is to be made. Take any set of observations made when the shadow falls to the south of this line, points like A′ and B, for instance, A′ on the Western Arc and B on the Eastern Arc. Let O be the centre of the circle, join BO and A′O. Take off or deduct from A′O a length A′a equal to the correction figure. Then join Ba, this will give the true East and West line. This method was found fairly accurate when I took a few observations, the error being about 15 minutes in comparison to the reading obtained by a prismatic compass whose accuracy was not tested and the magnetic dip was not taken into consideration. Of course, it is dangerous to make a generalisation based on one or two readings, but it proves the correctness of the method.

Now let C and D be two points observed on a day when the transit of the shadow points is on the North of NM. Join OC and OD. If the correction is made along OC from C, it is obvious that the line, thus obtained, will still deviate from true East-West. On the other hand, if the correction is made on the left of the observer, on the line OD, from D making Dd equal to the given correction for the day, the line dC will give the corrected East and West direction. So the figures, given in Manasara, are not

far out, and the system is sound and based on extensive observations, probably extending over many years.

It may be noted that the correction-figures, given in Table (1), are the average for ten days, from which the minimum for the beginning and the maximum for the end of the periods need to be taken for greater accuracy.

Manushyalaya-Chandrika and Silpa Ratna give a second method for correcting the shadow. For this purpose a second observation of the shadow is taken on the morning of the second day, when the shadow touches the western arc of the circle, care being taken that the gnomon has been kept in the same position as of the previous day. Let A′ and A″ be the points on the western half of the circle (Diagram 2), showing the position of the shadow on two successive days, while B is the point on the eastern half noted on the first afternoon. Divide the arc A′ A″ into three equal parts, making A′A one-third of A″A′. Join AB, then AB gives the true east-west line.

This method of correction is not given in Manasara-Silpa Sastra. But there is some indication in the text to show that this or some similar method was known to its author. For, in Chapter VI, Stanza 25-28, it is stated that after the first day's reading the gnomon should be left on the spot. If there was no intention to take a reading on the next day, there would have been no need for such a stipulation.

The accuracy of this method was also tested by me though only on two occasions; but the result obtained was fairly accurate. The result, thus obtained by this method, was checked with that obtained by means of a prismatic compass, and the difference between the two was about half a degree. The points and lines in these cases were marked on a drawing paper, but if the lines

were drawn on the ground, the difference would have hardly been perceptible. The ancient Hindus had certainly other means of finding the correction for greater accuracy, and that was by mathematical or astronomical computation, while the above method was for the rough and ready use by practical Silpis.

In carrying out the experiments, I used a gnomon made of hard and well seasoned Sheesham wood, 9 and 1/32 of an inch long, one and a half inches in diameter at the bottom, tapered to three-fourths of an inch at the top with a rounded end in one case, and a lotus bud shaped one in the other, for both kinds are mentioned in the text. For making a few solitary points on the circumference of the gnomon circle, both kinds of pegs were found equally good, hence the soundness of variance in the specification; but if one wants to plot several points all along the transit of the shadow from the western to eastern arc, the more pointed or the lotus-bud shaped one was found to be better. For, it gave a better shadow point in approaching the centre of the circle, though at or beyond the centre great care was needed to eliminate the penumbra. The object of the ancient Silpis, in laying down that the diameter of the Gnomon Circle should be four times the length of the gnomon peg, also became apparent when experiments were made, for, it was only at this circumference that the best pointed shadow, least disturbed by the penumbra, was obtained.

The best period for taking these observations, is stated in certain books, as the months when the sun is in the northern solstice, and that too when the moon is on the increase. If I had followed this guidance, I would have had no occasion to cry over the non-completion of some of my experiments, due to inclemency

of the weather, though they were begun when the sky was clear, and the clouds and rains were least expected.

It is not given in any of the texts how this thumb-rule of one-third the difference of the readings of two consecutive mornings had been arrived at by the ancient Silpis, in the shadow correction. However, I venture to give the following explanation:—

Were the Sun and the Earth stationary and had no relative motion, the position of the shadow at A′ would have been stationary; but it was the relative motion of the Sun and the Earth that changed the shadow from A′ to B, between the periods of the morning and the afternoon observations. And it was the same cause which changed the shadow from A′ to A″ between two mornings, say within the period of 24 hours. Therefore, if the period of the transit of the shadow between the morning and the afternoon can be ascertained, that period should bear the same relation to the error caused in the transit of shadow from A′ to A″. Let x be the deviation in the transit of the shadow from A′ to B and t the 'time taken, and if arc A′A″ represents the error say in 24 hours, then

$$\frac{x}{t} = \frac{A'A''}{24} \text{ or } x = \frac{t}{24} \times A'A''$$

should represent the correction.

From the observations, I made, it was noticed that the transit of the shadow from points analogous to A′ and B took eight hours thirty-nine minutes on 12th April, 1935, and five hours fiftysix minutes on 18th January, 1935; if the average transit period throughout the year is taken as eight hours, the displacement of shadow in eight hours is one-third that of 24 hours. Hence the thumb rule or approximate correction method, given in Manushyalaya Chandrika and Silpa Ratna, can be considered as fairly accurate.

In establishing thus the correctness of the Manasara shadow correction figures, the Malayalee Silpis will be greatly disconcerted, for, it is generally known in Malabar that the shadow needs no correction if the gnomon is set up about the first of their Mesha, or Meta; and accordingly, that period is often utilised for establishing correct orientation of buildings. But according to Manasara, it is at the commencement of Vrisha, that the shadow needs no correction. Why then is this discrepancy? If no explanation can be found, either the Manasara or the Malayala Silpi is wrong. This discrepency will be obvious from the Diagram (4), in which the shadow correction figures in respect of corresponding months of belt (I) are given as shown in the Manasara; the tortoise like figure in the centre is the diagramatic representation of the shadow correction figures. The belt (II) gives the English months corresponding to Manasara months; the belt (III) gives the Malayalam months corresponding to the English months of belt (II). The English months are shown here, because it is in comparison with these that the discrepancy between the Malayalam and the Manasara Zodiac will be apparent; Manasara Zodiac is one division or 30 degrees ahead of Malayalam Zodiac. The name of the Malayalam months and the Manasara months are the same, except for the fact that the Manasara months are Sanscritised.

The first of Meta, one of the two days when the Sun rises in true east according to the Malayalam Silpis, is a great day for the the Malayalees. In fact, it is their second greatest day of the year, the first being their "Onam" day. The first of Meṭa, they call Vishu. Vishu is the name for the vernal equinox and the word is probably of Tamil or Dravidian origin. The Vishu day is ushered in by the Malayalees with great pomp and ceremony.

Early in the morning one opens ones eyes on a circular brass tray filled with gold and laburnum, beautifully decorated round a cocoanut placed over spread rice; this is brought in with a lighted lamp. Then one dispenses and receives presents. The day is spent in amusements and feasting. Even the departed ancestors are not forgotten on this festive occasion; they are offered food and libations according to their liking; those who were fond of meat and spirits when alive are also provided for. The Malayalees speak of this as the New Year's Day of a forgotten era. But the actual New Year's Day of the Malayalees in Travancore comes full four months later, at the commencement of their "Kollam Era", on the first of Chinga. It will be noticed that on this occasion too the Sun's shadow needs no correction. The commencement of this Era was in 825 A.D. Yet there is another "Kollam Antu" or era in that part of the Malabar coast, which is at present known as British Malabar. The Travancore Kollum Era said to have derived its name, from its inauguration at a town called Kollam (the English Quilon), in commemoration of some great charitable act done by a king of Travancore. If the name "Kollum" is derived thus, how does the same name become applicable to an Era of North Malabar is not known. The explanation may be that in Malayalam language Kollam means Antu or year, hence, when it is said say 957 Kollam, for instance, as it is done by the natives, it does not mean that it is the 957th year of the Kollam Era, it only means the 957th year. The European writers presumably have taken the expressions like the 957th year as the 957th year of the Kollam Era.

The so-called Kollam Antu or Era of the North Malabar commenced in 825 A.D. This era, according to some writers, dates from the departure of King Cheraman Perumal, who

embraced Islam, went to Arabia, where he became recognised as Abdur Rahman Samiri, king of Malabar, and whose tomb is still seen in Zahfar (Arabia). The retention of the title Samiri, which is the Samirin in English, or Samuthiri in Malayalam, shows that he did not abdicate his throne on becoming a Musalman. Was it possible that the Malayalee Hindus, who are even now the staunch custodians of orthodoxy, would establish a New Era to commemorate the departure of a king who, according to their idea, had become a renegade and untouchable? In fact, the nobles of Malabar, who happened to know of the convertion of the king to Islam and sudden disappearance from the place, to hide the shame and to avoid a scandal invented a cock and bull story, for the consumption of the ill-informed, in which it was given out that the King Cheraman's sudden disappearance was due to his translation to heaven, in flesh and bone; and as he was to return, orders were issued that his shoes and walking stick should always be kept in readiness for him. But it is not the ill-informed that generally study the course of the stars and establish new eras. This epoch making era of Malabar is based on siderial reckoning and dates from the Sun's entry into Kanya of Manasara Zodiac, on 1,434,160th day of the Kali-Yuga. It should be noticed that when the sun enters Kanya, of the Mansara Zodiac, the shadow correction figure is zero and the Sun rises in the true east, at the Winter Equinox. If King Cheraman Perumal had run away on this auspicious occasion, it cannot but be a coinicidence. It appears that there was a great deal of cultural activity on the Malabar coast at this period, and great jealousy existed between the rulers in different parts. The mere fact that the King of Travancore started a new era would have been sufficient for any King in Malabar to start another era.

The year, which begins with Vishu or the Sun's entry into Meta, appears to have been the oldest era in India. The Bengali year of the San Era, which was inaugurated in 593 A.D., begins with the Vishu or the Sun's entry into Meta, so is the current Tamil year, the date of the inauguration of which is hidden in obscurity. All celebrate the Sun's entry into Meta, or the Vishu day; even the aboriginies, who have resisted the Hindu culture and influence so far, give special importance to the day. The aboriginies, like the Mundas, the Santhals and the Orans, follow the British in celebrating the New Year; for, they give more prominence to the New Year's Eve, at which they perform the Bhokta or Charak, or the hook swinging ceremony; and the whole night is spent in singing, dancing, drinking, taking out processions, and other kinds of merry making.

The Malayalees name their months after the Rasis, or Zodiac signs, while the Bengali and the Tamil do not follow this practice; in fact, nobody else in India follow the Malayalees practice, whether their calendar is Solar, luni-solar or lunar. In Diagram (4) the belts (IV) and (VI) show the names of Bengali and Tamil months corresponding to Malayalam months, while the belt (V) shows the names of the Hindi months, which in some modified form or other are prevalent in all parts of North India. The names of the Bengali months and the Hindi months, though with slight difference in pronunciation, are the same; the names of the Hindi months, given here are just the same as those given in Kautilya's Arthasastra, a book written in the 4th century B.C. In the north there appears to have been no solar calendar, perhaps except for the Bengali calendar. Judging from Kautilya's Arthasastra, the reckoning prevalent in the 4th century B. C. was Luni-solar. So was the computation of the Vikramaditya Era,

which commenced on the 18th September, 57 B. C. The Saka Era, which probably commenced on the 3rd of March, 78 A. D., was also Luni-solar. It does not appear that any serious attempt at a purely solar reckoning was attempted in North India, for civil purpose.

Before the days of Varahamihira, who introduced a Solar or Siderial reckoning from 19th March, 505 A. D., the Tamils appear to have had a Solar Calendar. About their solar calendar, Dr. Gilbert Slater says that it "is truly and completely solar, that it does not even concern itself to make a month consist of so many days. The Eclyptic is divided into twelve divisions and whatever moment in the morning, noon or night the sun enters a new division, at that moment the month begins. The days begin at sun-rise, not the local time of sun-rise for any place in India, but at the calculated moment of sun-rise at a spot on the Equator, which is also the meridian of the ancient Tamil Observatory. I do not know whether any one has ever assigned a date to the adoption of this unique calendar. That it is unique, and it aims at a degree of astronomical accuracy and consistency beyond that of any calendar in use, even at the sacrifice of some practical convenience,-is very significant. It proves the independent and continuous activity of the Dravidian science in that part of India exposed to non-dravidian influence." This calendar does not appear to have penetrated to the north.

The Tamils, in addition to their Solar Calendar which they appear to have used for Civil Purposes, had an ecclesiastical Calendar which, in fact, is purely Lunar, and appears to have existed side by side with their Solar Calendar.

A glance down to the columns 4 (a) and 5(a) of the Table (2) will convince one of this presumption. The columns 4 (a)

and 4 (b) show the 27 fold division of the Zodiac after 27 Nakshatras or constallations, while columns 5 (a) and 5 (b) show the division of the Zodiac into 12 equal divisions. Each indicating a month. On comparison it will be seen that the names of the months in column 5 (a) are derived from some Nakshatra opposite to it in column 4 (a). The month Chithirai got its name from Chithira Nakshatra ; Vaikasi got its name from Visaka Nakshatra ; similarly it will be seen that the names of all the months are derived from the Nakshatras, opposite to the respective months except in the case of the month Ani, where the name is borrowed from Anizam Nakshatra, opposite to the month previous to it. It will be noticed that the corresponding Sanskrit month, Jaishta, too took its name from Jaishta Nakshatra opposite to the month Vaisakh. This may incidentally show that there was some confusion about the position of certain Nakshatras at the time of naming the months, and that mistake had been continued for ever. Tamil names of both the Nakshatras and the months appear to have been Sanskritised as shown in columns 4 (a, b) and 5 (a, b). The entertainment of a reverse process may not be tenable, in view of the fact that " the phonetic system of the Sanskrit itself is intermediate between that of the Tamil and other Dravidian languages and that of the Indo-Germanic languages on the other". Dr. Gilbert Slater, (the author of " The Dravidian Element in Indian culture ") states that " even when the Rig-Veda took the form in which it has come down to us, a considerable part of the Sanskrit speaking population was of Dravidian race". Hence it may be safely assumed that the Sanskrit names for the Months and the Nakshatras have their origin in corresponding Tamil words. The Dravidian influence in Aryan culture is now an established fact. Some European scholars go to the extent of

tracing the Hindu castes and religion and even the habit of wearing the "sacred thread" to Dravidian sources.

The division of the Zodiac by means of the 27 Nakshatras appear to be of pure Tamil origin, for, the Nakshatras play a great part in the lives of the people in the south, where the cleberation of birthdays and other ceremonies are observed according to the Nakshatras; while they are invariably done in the north by Thithis or dates based on the phases of the Moon. Even the observance of the birthdays of Sri Rama and Sri Krishna, the semi divine beings, are reckoned by Tithi in the North. The Rama's birthday is called Rama-Navami, the Navami on the (ninth day of the Moon) on which Rama was born. Krishna's birthday is known as Krishna-Ashtami, the Ashtami or the eighth day of the Moon on which Krishna was born, while Krishna's birthday is observed in the south on Ashtami-Rohini day, that is, when the eighth day of the Moon comes with Rohini-Nakshatra. Krishna-Ashtami and Ashtami-Rohini sometimes are not on the same date, sometimes there is a difference of about one month between them. The division of the Zodiac by the Nakshatras does not appear to have much standing in the North until the 6th century A. D.; even then, according to the Surya-Sidhanta, the north Indian Astronomers divided the Zodiac belt into 27 equal parts, called Bhogas, the first point of which shifts like the Solar signs. The Tamils divided the Zodiac into, twelve equal Rasis. To each of these twelve divisions they gave a name; Meta, Etawa, Mithuna, Karkataka, etc. The first division of this Zodiac begins with the apparent Sun's entry at the celestial Equator. The moment the Sun appears on the spot in the celestial Equator, they called Vishusankrama and the day, on which this took place, they called Vishu. The moment is also known as Ravi-meta

Samkrama, which means the entry of the Sun into Meta Rasi, or division. Each of the Rasi division represents 30 degrees, making the Zodiac circle 360 degrees. The next Rasi begins at the conclusion of the 30 degrees and at the commencement of the 31st degree and so on, at the end of each 30 degrees a new Rasi begins. The introduction of the Rasi divisions caused some adjustment in their lunar Calendars the months of which begin from the 1st day after the Full Moon. These Rasis correspond to the twelve asterisms of the Egyptian or the Greecian Zodiac.

This is cited as an instance of Greek or Egyptian influence on Indian astronomy. But Reginald J. Waterfield (the author of "the Revolving Heavens") does not credit the Egyptians or the greeks with the naming of the 12 constellations of the Zodiac belt, as it was impossible to see all these constellations from their geographical positions; he is of opinion that it was done by the Chaldean astronomers from " what is now Iraq." If the Chaldeans had seen all these constallations, the Tamils could have seen them with greater fecility from their observatory under the equator.

The Tamil legend and the picture representation of the Rasis, have a family likeness to the symbols of the Alexandrian Greek. The Tamils indicate the Rasis with certain animals or objects; the counter part of them will be easily seen in the symbols of the Greek or the ancient Egyptian.

The Rasi names have a peculiar Tamil flavour and legend about them. They say Meta is like an Atú, a goat; Etawa is like "Ethirú", a bull; Mithuna is like Vina, a two stringed instrument (a native of south India), Karkataka is like " Karka " a kind of crab; Chinga is like " Chingam " a lion; Kanni is like Kanya, a maiden; Tula is like Turas, a balance which the gold-smiths use even now in weighing precious metals and gems; Vrischika is like

Vrischikam a scorpion ; Dhanu is like Thanu, a bow ; Makaram is like Makaram a peculiar kind of sea-fish which is freely carved on ancient temples in the South, and in some parts of India where the aboriginal tribes are prominent ; Kumbha is like a "Kumpam" a pot which the villagers commonly use ; Mina is like " Min", Tamil for fish. With the development of the Sanskrit language, the Tamil names of the Rasis appear to have been Sanskritised. Meta became Mesha, Etawa became Irshabha or Vrishabha, Mithunam became Mithuna and so on, as shown in Table (2), column (2) (a) and (b). Their corresponding Egyptian Hieroglyphic signs and Greek names are shown in col. 6 (a) and (b). Some of the Greek names cannot but make one think of a possibility of their derivation from the Tamil, as or if the Tamil language is earlier than the Greek. For instance, Meta, which is like an Atú, is the Greek Aries, from which when the peculiar Greek ending is removed becomes Ar, or Aṛ, where r with a dot below sounds as t. Similarly Taurus without the Greek ending may become 'theiú, or Ethirú. In respect of the remaining asterisms, a translation of the Tamil legend, attached to the Rasi names, into Hieroglyphic signs may become a possibility ; for, it is more probable,—the Tamils observing a cluster of stars with the outline of a Vina, their special musical instrument and the Egyptians representing it by the sign II, after the two strings of the Vina, which is the most characteristic feature of it, than the Tamils taking the sign for two from the Egyptians or the Greeks and associating it with their musical instrument ; the two could have been symbolised in many ways other than the shape of a Vina. The same may hold good in respect of other signs too. This may sound heresy, but an investigator has nothing to do with heterodoxy or orthodoxy.

According to Waterfield and other western astronomers, the First point of Aries was fixed by Hipparchus some 2,000 years ago, and now it is not at the same place as it was then, and since then, it has moved about 30 degrees, as "the precession has carried the equinox out of the constellation Aries into the neighbouring constellation Piscus." The Manasara Zodiac shows a similar difference of 30 degrees with reference to Vishu or Rasis of South Indian Calendars. Was the Manasara Zodiac influenced by Greek Astronomy ?.

G. Thibaut, the translator of the Varahamihira's Pancha-Sidhantika, from obscure Sanskrit into English states "that the Hindus learned from the Greeks", and Varahamihira, "at any rate mentions certain facts and points of doctrine which suggests the dependence of Indian Astronomy on the Science of Alexandria." One of those main points appears to be a statement by Varahamihira in which a reference is given to the longitudes of Yavana, Ujjain and Benares. In Pancha-Sidhantika, Chapter III, Stanza 13, Varahamihira states ;—" The Nalikas arriving from the difference in longitude from Yavana are $7\frac{1}{3}$ in Avanti and 9 in Varanasi." Varanasi is Beneras, Avanti is Ujjain, while Thibaut states Yavana stands for Yavanapura, that is, Alexandria. Without going into the intricacies of Nalika, which here is a measurement of time in degrees, from the relation between the meridians at these different places as given by Varahamihira it is evident, that the difference between the meridians of Yavana and Avanti is 4.4 times the difference between those of Avanti and Varanasi ; but actually the difference should be about six times that of the other. From this it may be clear that Varahamihira was not referring to Alexandria, or his meridian computation was absolutely wrong, or if he had copied it from the Greek, they were wrong. Further

that a comparison made of the longitudes between the three places, is no criterion that the Meridian of one of the three places, in this case, that of Yavana, was the Standard or the zero meridian, as it is assumed by Thibaut.

Similarly Thibaut's assertion that the Indian astronomers reckoned the beginning of the day from the sunset at Yavana (Pura) (Alexandria) is fallacious. Yavana for the Indian astronomers stood for a place in the west towards the Sunset, just like some other conventions of theirs. For instance it is given in Pancha-Sidhantika that "what is sunrise in Lanka is sunset in Sidharpura, midday in Yamakoti and midnight in Romaka country". Romaka country is taken by Thibaut and others as Rome, which does not fit in, for to cyncronise with the Sunrise at Lanka, the Sunset should be in Liberia or in England and not in Italy. Where are the two other places, Yamokoti and Sidharpur? Yamakoti should be in New Zealand of which the Tamils appear to have had special knowledge and Sidharpura in California. The statement perhaps only indicates the rotundity of the earth's surface, conception of the antipodes, or the fact that the Sun-rise at one place is sunset at another and that midday at one place is midnight at another. The Hindus designated the North pole Sumeru, the abode of gods, hence they had to designate the South Pole the abode of Asuras, the opposite class of people to the gods or Suras.

Everything that is given in Pancha-sidhantika cannot be taken as true to the letter, for, many interpolations and transcriptions might have taken place since it was framed first. If one is to judge Varahamihira from what he is supposed to have stated in Pancha-Sidhantika, he may go down in our estimation. For instance, take Stanza 6, Chapter III of Pancha-sidhantika which reads thus:—"Others maintain that the Earth revolves as if

it were placed in a revolving engine; if that were the case, the falcons and other (winged creatures) could not return from the ether to their nests." This shows clearly that the author of this statement did not believe that the Earth was revolving on its own axis, though it may seem that some of his predecessors believed it to be so. Was Varahamihira influenced by the opinion of the Alexandrian Greeks? Though Pythagoras (572 to 500 B. C.) and Philolaus taught that the Earth rotates on its axis, and was not fixed in space, later on Aristotle (384-322 B. C.) asserted that the earth formed a fixed centre to the universe; and that opinion of Aristotle was shaken only in 1610 A. D. by Galileo Galilei, who asserted that the earth was revolving on its own axis and suffered for this heresy at the hands of the Roman Catholic priesthood.

Even Ptolemy, the founder of the Alexandrian Greek school of astronomy, held the opinion that the earth was fixed and the planets moved round it in cyclic and epicylic paths. To India, there was a flow of Grecian philosophers and wine from the days of Bindusara, the father of the Great Asoka, from the 3rd cenutry. B. C.

Pancha-sidhantika does not appear to be more than an intelligent scholar's note book on the study of five astronomical works. The five Sidhantas, which Varahamihira commented on were the Paulisa, Romaka, Vasishta, Saura, and Pithamaha, of which he says that the Paulisa is accurate, the Vasishta, Saura and Pithamaha more accurate, while Romaka comes between the two groups. There were other astronomical works like the Parasara, Jyothisha Vedanga, Garg Samhita, etc., from which the Hindu attainment in astronomy should be judged. If we judge the Hindu attainment by Pancha-Sidhantika alone, we may be doing an injustiee

to Hindu Astronomy. Thibaut came to the conclusion that the Indian Astronomy is mainly based on pre-Ptolemic Greek astronomy, though he confesses that "our knowledge of Greek astronomy, anterior to Ptolemy is so very imperfect." Whether or not the Indian astronomy was based on the Greek astronomy, it cannot be denied that there are some points of similarity between the two schools; one of them may be cited as the virtual synchronisation of the Manasara Zodiac with the Greecian Zodiac. If it is not the result of independent growth, it cannot be said without substantial evidence that the ancient Greeks were influenced by the Hindus, or the Hindus by the Greeks. But evidences are not completely lacking to show that the Anatolian Greeks from the days of Pythagorus used to visit India to meet the Brachmanes (Brahmins) to study their wisdom.

However this may be, the system, upon which the Tamil Calendar is based, is undoubtedly of great antiquity, and it was a system of their own, unless they were influenced by the ancient Egyptians, who had a sidereal Calendar which can be traced back to 2719 B. C. The year of this Egyptian calendar also begins with the summer solstice, though their previous Calendar (Seth) appears to have started from the autumn solstice, 372 years eariler. The Mediterranean race, who were the preponderant element in the Dravidian population of the South, being next door neighbours to the ancient Egyptians, probably may have brought the Solar Calendar with them, or the Tamils might have got it from the Egyptian Traders, who visited the Indian coast from the days of VI Dynasty (2420 to 2294 B. C.). But the mediterranean element, who came to India, were only the "harbingers of Heliolithic culture," but not of the Egyptian culture. However, there is a great probability of the contact between India and

Egypt influencing each other's culture. But the Egyptians in those days had nc Rasi divisions, and they seem to have known only about half a dozen constellations of the zodiac belt, the numbers which Ptolemy was able to collect about 100 A. D. From Pancha-sidhantika it is evident that they have been dealing with fixed and movable Zodiacs. The fixed Zodiac they called Nirayana, and the movable Zodiac Sayana, and the difference between the two was adjusted by Ayanamsa, a figure arrived at by taking into consideration the years passed between the date of the fixed Zodiac and the date of observation and the precessional variation at the rate of $50\frac{1}{3}$ second per year. Varahamihira calls the process Bija correction, which "signifies any correction, applied to astronomical elements, which aims at bringing about an agreement between the celestial phenomena such as are actually observed." In Pancha-sidhantika the following rule is given—" Deduct the Saka year 427 at the beginning of the light half of Chitra when the Sun has half set in Yavana, at the beginning of Monday". As Varahamihira's Epoch is said to be in 505 A. D. and if 427 Saka year is deducted from it, we will get 78 A. D., which is the commencement of the Saka-Era. From this it will be evident that the fixed Zodiac, which Varahamihira had in view, was the one fixed in 78 A. D. But the present day practice among the Hindu astrologers varies; they use such varying figures as A. D. 559, 498, 397, 394, 361, ete. instead of Varahamihira's 427. A proper fixation of this date may explain the discrepency between the Manasara Zodiac and the South Indian Zodiac.

By looking up South Indian calendars it was found that in the year 1944-45, the Vishu, or Surya-Mesha Samkrama, was on the 13th of April. As from the Saka Epoch of 78, A.D. to 1945

A. D. 1867 years have passed, the first point of Meta on that occasion should have been about 26 degrees ahead of its present position. And if Manasara's Mesha being approximately 30 degrees ahead, the Epoch, which represents Manasara's Zodiac, should be approximately about 2145 years ago, or 200 B. C. (In both cases the precessional variation has been taken as $50\frac{1}{3}$ second per year, which is the recognised Hindu figure, though it is slightly less in fractional part than the present day figure,) No fixation of Mesha is known to have been done at this period in India, though such an assumption may explain the discrepency between the North and South Indian Zodiac.

It was about this period that Hipparchus, (died about 125 B. C.) fixed the First point of Aries. However, this cannot be cited in favour of the Indian Astronomy being influenced by the Greecian, or vice versa. But it will show simultaneous activities in Alexendria and India. The days of Hipparchus was "a flowering period" in Alexandrian science, while in India at this period, Patanjali, the Great Grammarian, was writing Mahabhashya and Buddhism was rampant in its activities. No doubt, India and Greece were in touch with each other, and there was no difficulty for "the twins," the East and the West, "to meet," as it was in the good old days prior to the Christian Brotherhood. Why, even Hipparchus was an Asiatic, born at Nicaea in the ancient province of Bithynia, the home of many a Greecian scientist. However this may be, the shadow correction figures, given in Mansara, are correct despite the difference in the names of the months. They are correct in relation to the time of the year, or they are correct in relation to the movement of the Sun and the Earth. In fixing the true East and West, it is only the Earth's motion in relation to the Sun that counts.

The Silpis, after having fixed the true East-West line, proceeded to fix the other cardinal points, by means of simple geometrical constructions which for ages In India had been preserved in the so-called mystic diagrams of the "fish" and the "padma," used in Poojas, "homas," and wall decorations.

In the diagram (5), let the line EW represent the true East-West Line, fixed by the observations of the Sun's shadow. On EW take any suitable points C_1 and C_2 equidistant from the centre O. Then with C_1 and C_2 as centre draw two convenient circles with equal radii to intersect at S and N. The figure, formed within the intersection of these two arcs, is known as the Makara, fish, probably due to its likeness to the body of a fish. Join the intersection points S and N; the line SN will give true North and South. Then on EW mark the distances OE_1, and OW_1, equal to OS or ON. With the centres E_1, S, W_1, and N draw four circles passing through O; the intersections of these circles give the N-E, S-E, S-W and N-W cardinal points. The four petalled diagram, thus formed, having the appearance of a lotus, is called Padma. The East-West line they called Brahma Sutra, the North-South line Yama Sutra; while the other two were called "Karnens." In their scheme of survey, as will be seen later on, there were several East-West and North South lines; to differentiate these main ones from the rest, they seem to have given these proper names. The proper names, they gave, do not seem to be without significance. The names Brahma Sutra to the East-West line might have been influenced by the fact that it was the first line and all other lines were derived from it, for, did not Brahma create the rest of the world, and as for Sutra, it means a thread or a line. The line which cuts this across perpendicularly is called Yama Sutra; Yama is recognised as the god of death;

and the line in its action cutting across the original line or the life line of the diagram may represent this god in his traditional action of cutting short life or the life line. The Karnans are the diagonals; the name may have derived from the fact that these lines are derived by the manipulation of other two, Karnan that which is the result of "Karna," doing. The eight cardinal points are named after the eight gods of the horizon, known as the "Ashta-Dikpalas." These gods, originally, might have been some fixed physical or geographical feature in these directions.

The East has always been associated with the Sun God. In India, once upon a time the Sun was known as Indra or Indi-Ra; while the ancient Egyptians called him by the name of Ra only. Ra was an Egyptian god, so was Amman; these terms for god are even to-day being used by the earliest inhabitants of Travancore, known as Parayas and Pulayas, who were released from slavery only about a hundred years ago. This Indira was not the Indra of the Puranas, who waged war against the Aṣuras, and whose love episodes and defeats were the great theme for poets and story tellers.

The name of these gods, as given in Amara-Kosa, the great Sanskrit Dictionary, are: Indra, Vahni, Pithrupathi, Niturthi, Varuna, Maruth, Kubera, and Isa, respectively counting from the east to north-east in a clock-wise direction. See diagram (4). The God on the South-East corner is Vahni, the god of fire, and is most appropriate, it being the direction of the greatest heat. The opposite corner to Vahni, the north-west, is guarded by Maruth, the god of wind, the north-west being the direction of the prevailing wind. The god in the south is called Pithrupati, the guardian of the dead. The south is always associated with death in India; the dead bodies are buried in the southern side

of the compound; cremetoriums generally used to be on the south of the city or village or house; the rites for the Pithrus or the departed ancestors are performed facing south. Why the south has become a symbol of death, is not certain; most probably it is due to the presence of the vast death-giving and unknown region of the Indian Ocean in the South. It is often argued that for the Aryan invaders, the south always spelt death on account of the hostile presence of the Dravidians; but this argument is not tenable, as for the Dravidians of even the most remote Southern part of India, who had never come under the so-called Arayan influence, the south is dreadful and a place of death, to be avoided. The expression "gone south" has the same significance in South India as "gone west" has in the English slang. The diety in the South West is Nirurthi, or Gagana, the god of the Sky; and in him they saw the great activities of nature, such as the approach of the rain-bearing clouds, the south-west monsoon and the storms. The west they assigned to god Varuna, the god of the Sea, the Arabian sea, which was known, hospitable and useful. Varuna and Mitra are the two gods brought, according to some, by the invading Indo-Aryans from an unknown north-west. But it is a point that can be settled only on a final decision whether the Indo-Aryans went out of India or came to India. However, if they had come to India, through the north-west from any of the several places from which they are supposed to have come, Varuna as the god of the seas will lose all significance. The North is given to god Kubera to protect. Kubera is the king of wealth. Perhaps this might have had a reference to the virgin fertility and wealth of the Gangetic plain. The north is considered very auspicious by the Hindus, even before its magnetic and spiritual importance had been explored by the Theosophists

or mystics. The ambition of every man from the South is to go to the North and the practice of every Hindu except the Rajputs, is to cremate the dead facing the north. Why? The only parallel in History is found in the case of Munchung invaders of China. They came from the north; their ambition was always directed towards the south; their thoughts and actions were centered round the conquest of the south, and the wealth of the south; their kings and queens used to hold their court, facing the south, and even when they were buried, their faces were made to look towards the south. The presiding deity in the North-East, is Isa. The term Isa means God; but what peculiar quality or characteristic of god was the point of observation, is not known. Perhaps, it may have had some reference to some high peaks of the Himalaya Mountains; but this interpretation would be rather far-fetched, for, these mountains are still awaiting exploration. Had it anything to do with the north-east monsoon? The monsoon that brings the thick dark blue clouds high up in the sky with mysterious electric flashes, roaring sounds of thunder, and sudden deluge of rains? It is possible that the most ancient Hindus might have seen the symbol of God more in this than in anything else. It is interesting to note, that later on when they made the historic Krishna a god, the colour, given to his body, was Kala-Megha, the same colour as that of the clouds mentioned above.

Now if one had not heard of anything about the Aryan invasion of India, or on the origin of Hindu culture in Brahma Desa, he would have set out to find the cradle of Hindu Civilization in a locality or country, where the cardinal points coincided with the physical features that can be attributed to the gods at the Ashta Dik or the eight (cardinal) directions.

CHAPTER III

Hindu System of Surveying

THE SURVEYING, AS IT IS UNDERSTOOD TO-DAY, WAS NOT known in Ancient India; but they had a remarkable substitute. The object of survey is to have before the designer or the architect, a view of the field with all its peculiarities and details. The earliest method of representing the field on paper was to make a number of squares on the ground, then make similar numbers of squares on a board or paper and mark on it the objects noted in the field, square per square showing the respective distances from the sides of the squares. This undoubtedly was a tedious process; but the introduction of the surveying instruments, like theodolite and plane table, made the task easier. The present surveyor does not square the field, but he lays out three or more convenient lines on the field and marks the objects in relation to the lines, taking the bearing in angles and their distances in linear measure. But the Silpis had no such instruments and they had to depend on squares. The Silpi system of squaring is sunk in obscurity, just as all their other systems. The books, that deal with them, give a great deal of confused details, which cannot be explained even by those who practise them most religiously.

By their system, the Silpis, as if it were, created the field in their minds, with a certain number of squares; and these squares were identified by the names of certain gods, whose relative position were also fixed. This mental picture they carried on to the

field, and noted the features ofthe field in relation to the gods of the squares. The system was simple, when the field envisaged was small, and the squares were limited; but difficulty arose when large areas had to be dealt with. So they increased the number of squares, new gods were found, and practices became varied in different parts of the country. The result was confusion worst confounded. The introduction of the gods in the squares might have been unfortunate, but it is that which has perpetuated the system. The location of the gods was committed to memory, the displacement of a god from his allotted square or squares, was considered to be a sin; consequently, care was taken not to make any mistake in the order and procedence of the gods. Occasional worship of the gods in their respective squares made the practice ever fresh in memory.

It has already been shown what scrupulous care was taken to lay out the East-West line. It is often stated that this became necessary on account of the religious practice of the Hindus. It is admitted that a certain section of the Hindus may look at the rising sun, or follow its course in their prayer and meditation or other religious practices; but the sun's course is not always through the true east-west line, and there are not many religious ceremonies, in which a true east-west line direction is required; in fact, the majority of the people, except the aboriginal tribes and other sunworshippers, would prefer to look towards the north in the act of prayer or penance. The Hindu Silpis determined the true East-West line for the same purpose and with the same care as the present day surveyor lays down his north point, in the field as well as on the plan.

The eight cardinal points, and the associated gods having given the indefinite space certain specific directions, the Silpis

proceeded to fix its boundary by four lines, two parallels east-west and two parallels north-south. It has already been stated that the east-west line they called Brahma-Sutra and the North-South line Yama-Sutra. The eastern boundary line they called Aditya, after the Sun which rises in the east; the western boundary they called Varuna, after the Arabian Sea which bounds the land on the West; while the south and the north boundaries they respectively called Yama and Chandra, the former standing for dread or death, and the latter for coolness or delight. To the diagonals also they gave illustrative names. The one from the centre to the north-east, or Isa corner, they called Isa-Sutra. To the other portion of the same diagonal, from the centre to the south-west or the Nirurthi corner they gave the name Nirurthi-Sutra. The line from the North-West or Maruth corner to the centre they named Vayu-Sutra, for, Vayu was another name for Maruth, the wind; while the prolongation of the line from the centre to the south-east or Agni or Vahni corner, the names Agni-Sutra, or Vahni-Sutra, for, Vahni is a synonym for the god Agni. Refer to the diagram (6).

The four squares formed by the east-west and north south lines, they called after the respective deities of the corners :—

North-East Square. : Isa Khanda or division.
South-East Square. : Vahni Khanda or division.
South-West Square. : Nirurthi Khanda or division.
North-West Square. : Maruthi Khanda or division.

Having fixed the confines of the squares, they proceeded to fix the circle. The circle was to touch the main square at four points, north, east, south and west. The perephery of the circle they called Naga Sutra, or serpent line. Thus it is obvious that the squares and the circles were not abstract geometrical

factors to the Hindus; unlike the Greeks, they assigned direction and position. They then joined the points of contact of the circle with the square; and the four lines thus formed, they called Sulas, probably due to their appearance at the points outside the circle like that of a thri-sila or three forked spear.

The original or the main square, according to the Manasara, was called Sakala; Sakala means all or the whole square. The process of dividing the square into four smaller squares, is known by the name of Paisacha, according to the Manasara, and Pechaka according to the Mayamatha. Paisacha appears to have no literal significance, while 'pechaka' or its Sanskritised form bhejaka, indicates the process of division. The Manasara deals with the division of the main square from four to 1024 sub-squares, that is, by dividing the length and breadth from two to thirty-two equal parts; and its author has given names for each process. For brevity's sake, these names are not enumerated but some of the names may indicate the purpose for which those divisions were to be used; for instance, Pitha (nine squares) and Maha Pitha sixteen squares and Upa Pitha (twenty-five squares) indicate that these divisions were originally used in connections with the construction of plinths, while Sthandila (49 squares) and Sthaniya (121 squares) were used in connection with forts. Of the rest, Chandita (64 squares), Paramasayika (81 squares) and Asana (100 squares) seem to have been the most favourite and generally used.

From this, one is not to come to the conclusion that the ancient Silpis dealt only in squares; their mode of town-planning shows that they tackled circular, triangular, and other geometrical plots. But it should be admitted that their lay-out was based generally on squares. For, even in dealing with limited space,

say for the construction of a house, if the length was greater than the breadth, they left out a portion of the length to make the remaining area into a square. The length, according to their convention, was the east-west dimension; while the breadth was always the north-south dimension, irrespective of their magnitude.

The Paramasayika division of 81 squares is shown in Diagram (7), and the Chanditha division of 64 and Asana division of one hundred are shown in Diagrams (8) and (9) respectively. The names of gods may vary slightly in different texts. A comparison of these diagrams will show that even with the increase of the squares, an attempt had been made to maintain the relative positions of the gods. In the sixty-four division squares certain half-divisions were given to certain gods; while in the hundred division squares the gods are-pulled about to occupy the increased number of squares. Though the number of squares was increased to 1024, there was no corresponding increase in gods. The Hindu mythology is not lacking in gods. Still certain names, given to the squares, indicate that there was a dearth of gods at the time of naming the squares. The names like Sosha, Vithatha and Roga are significant; Sosha means sin, Vithatha means untruth, and Roga means illness; these qualities or abstracts are seldom seen deified, or made into gods. The square of 81 divisions shows that the deities of the eight cardinal points have been kept intact in their original positions, though in the other two systems they are pulled about to fit in with the number of squares. But it will be seen that in these diagrams, in comparison with diagram (5), the god Indu or the Moon has taken the place of Kubera, the King of wealth. The change in the conception of the North may denote a change in the idea of the people about the North. The North from a source of immense

wealth, associated with Kubera, became a place of coolness attributed to Indu, the Moon. Does it indicate a further penetration of the Hindus beyond the fertile plains of the Gangetic basin to the Himalayan regions? If so, what would have been the lapse of time between the fixing of the cardinal points and the introduction of survey? Of course, any suggestion of the Hindu penetration to the north, will militate against the spreading of Aryan culture to the south.

The system of dividing the plot into sixty-four is mentioned in Agni Puran, and it can be identified as the mystic diagram of the Vedas, called Mandala. But Agni Purana fails to mention the division of the plots into 81 or 100 squares. This may be taken as indicative of the earlier practice of the square into 64 divisions, but the author of the Agni Purana displays an unsuccessful attempt in squeezing within 64 squares, more gods presumably intended for 81 squares, thereby indicating indirectly a knowledge of 81 square-practice.

The division of the plot into 64 squares may also be seen outside India; it was the basis of the square measure used by the Maltese. Col. J. W. S. Sewell has shown, in an interesting article, how the Maltese, who on the wake of the Phoenicians went to Cornwall to work the tin mines, introduced their land measure in England and how the English Acre has derived from the Maltese Weiba.

The Maltese saquare measure:—

1 Salmi = 4 Weiba = 8 Palmi = 16 Tumoli = 64 × 64 canne.
This clearly shows that Salmi plot was divided into 64 squares first. Was this a mere coincidence? Or did the Hindus get their sacred and mysterious Mandala from the pre-historic Mediterranean race, to which the ancient Maltese belonged? Did

the Mediterranean colonizers of south India bring the sacred Mandala with them? If so, when? According to some authorities, the admixture of the people of the Mediterranean with the pre-historic Dravidians, seems to have occurred many centuries before the coming of the stone-culture. Did the Mediterranean race develop a system of square measure before attaining their stone age culture? If this is not possible, the other alternative, the influence of the Hindu culture on the Mediterranean race may become a probability. It may be noted that the word 'canne' of the Maltese sounds like 'Canna' or 'Cannam' in Tamil, meaning division or square. The words Palmi and Tumoli also have a distinctive Tamil softness about them.

The gods, representing the squares, were given different colours, and some were accompanied by their favourite animals and wives. Though the gods are bedecked with their respective war equipments; only one, namely Indu, is accompanied by a horse which is distinctly an animal, brought to India from the north. Then there is Arya or Aryaman, whom Manasara describes, "as usual, in the cow-like pose", which is not a very complimentary term to the conquering Aryan race. The colour for Brahma is golden, Aryaman is red, Mahendra is yellow and Yama is grey. It appears that they had not enough variety of colours to give one to each god, so repetition was inevitable. Even the Manasara, that goes into such details, fails to give the colour to all gods, thereby indicating most probably that the colour scheme was the first differentiation introduced for the recognition of the squares; and when the names of gods were introduced, the colour scheme took a secondary place.

The colour scheme is still maintained in certain "pooja" diagrams. The diagrams, used for daily poojas like Ganapathi

Homa and Bhagavati Seva, consist of squares, each of which is marked out in different coloured powders. The main powders, they used, were termeric for yellow, burnt husk of rice for black, rice powder for white, a mixture of termeric with quicklime for red, while green and other shades were made of powdered mango leaves, and such like, that gave satisfactory contrast.

It is clear that the names of gods were introduced as a guide to memory; but with the increase made in the number of gods, other methods had to be introduced. All books on Silpa-sastra refer to a demon, called Vastu, or Vastu Rakshasa; Vastu means land, Rakshasa means demon. This demon is supposed to be occupying the entire plot, however large or small; in fact, he occupies every plot that is taken for consideration. The story of the demon is given as follows :—

In ages gone by, there was a demon, called Vastu, who was very strong and powerful; and he was in the habit of terrorising the whole world. When the position became unbearable, all the gods combined together, fought, and succeeded in felling him down. Still his prowess was such that his essence used to permiate the entire land; and constantly circulating, it caused untold misery and trouble to humanity: as a result of which, both mankind and gods became very sad. Thereupon they went on a combined deputation to Brahma, the creator. Affected by this universal sorrow, Brahma fought and pinned the demon firmly to the ground, and as a further precaution, ordered a certain number of gods to sit on him and stop all his baneful activities. The way, the gods sat on him, is shown in the diagram (10). Here in the plot, divided into 81 squares, the Vastu Rakshasa is lying, and forty-five gods are pinning him down. The diagram also shows the relative position of the gods in the different parts of

his body. The demon then made representations to Brahma and told him that Brahma himself was responsible for his wicked deeds, for, had not Brahma created him as such. Struck with the force of the demon's argument, and with the partial truth of the accusation, Brahma, as a mitigation, allowed him to receive offerings from the people. And this offering was to be given him at stated intervals, at the commencement, in the intervals and on the completion of all constructions. The offering, given to him, is known as Vastu Bali, *i.e.*, sacrifice for the demon, Vastu. But he seems to cherish his food through the mouth of the gods, for the sacrificial food is according to the taste of gods sitting at the different parts of his body. The Vastu Bali is still being practised in some form or other in every part of India. The articles of offering, according to Agni Purana, consist not only of meat and grains, but such delicacies as kidney, bird's tongue, beans, butter, sweets, wines etc.; the indulgence in liquor is a rule rather than an exception on these occasions. The offering is done by the Chief Silpi; the offered articles are distributed freely among the participants.

The Vastu Rakshasa, as indicated in the diagram (10), is lying on his back, with his face upward, his head in the north-east corner; and from the position of hands, feet and the rest of his body, it is obvious that he is occupying a very uncomfortable position. This position is according to the directions given in the "Vastu Vidya", but according to Manasara, the spirit of the site lies with his face down, head east, left hand in the north-east, right hand south-east, right foot south-west, and the left foot north-west; a position which is not so bad as the previous one.

First his position was said to be with his face down and according to "Silpa Ratna", this was due to the fact that the

spirit of the site prostrated at the feet of Isa, the god of the north-east corner. What has happened since then, or what has made him turn on his back, is not known. However, if his position can be changed like this, with the reversal of gods on his limbs, the orthodox will realise that his position as a whole is not of much consequence. As it is so, what was the object of creating and confining him to the squares? The whole thing is childish, and it is a story invented by a clever teacher, or by a cleverer student, who realised the difficulty of remembering the gods in relation to the squares. As the mental visualisation of a large number of squares was difficult, a colour scheme was introduced which differentiated one square from the other. Fewer colours and more squares made the scheme a failure; then the gods were made to take the place of colours, that proved to be better, but to remember the relative position of so many gods was still a difficulty, and to overcome this, the demon was felled on the floor and gods were located on his body and limbs. It was an excellent scheme, but in course of time, the object of the story was forgotten, the skeleton remained in the books, and being associated with gods, superstition grew round it. The utility of the story cannot be denied. In spite of the elaborate descriptions given in the texts, I found it difficult to locate the gods in their correct places until I had recourse to this cock and bull story of the demon.

The Silpis assigned certain gods outside the confines of the squares as well, see Diagram (10). These were placed at the eight cardinal points, though they are entirely different from the Ashtdik-Palas or eight presiding deities, mentioned in Chapter I. These deities are as assigned and reckoned from the North East corner, in clockwise direction, Charaki, Sarva-Skanden, Vidaryan, Aryama, Poothana (or Poothanika), Jrumbhakan, Paparakshasi

and Pili-Panchakan. Of these Charaki, Poothanika and Papa-Rakshasi are decidedly names of Rakshasis, or female malignant nature spirits, who roam about in the outskirts of the town or village and terrorise the people and whose propitiation is done by witch doctors even to-day. Pila-panchikan and Jrumbhakan are male spirits with the same characteristics as of their female species. Sarva-skandan is Siva himself, probably in one of his most atrocious forms. Aryama and Vidaryan (educated Aryan) appear to be milder beings, judging from their names, but both of them are Aryans. How did the Aryans get mixed up with the demons? It should be remembered that Arya or Aryama originally occupied a conspicuous place inside the square in the East with his cow like pose; why was he or like of him here placed out in the open? It appears when the deities of the old eight cardinal points were taken inside the squares, they had to find fresh gods to occupy the places outside. However, the four corner gods and other outside gods look like drawing pins, by means of which drawing papers are fixed on tracing boards. This completes the idea of squaring as a drawing.

The expert Silpi goes about with the mental picture of all these squares with gods; and superimposes the squares on the ground. By observing the path of the Sun he decides the east-west line; by the knowledge of the relative positions of the Ashta-dig-palas, he determines the cardinal points; strings, stretched out on the site, give the length and breadth of the area under consideration. Equal division or folding of the strings gives the number of squares; *e.g.*, if the string is folded into nine equal parts, it gives 81 squares; if it is done into ten equal parts, it gives 100 squares and so on. Then knowing the sequence of the squares, and where the respective gods reside, he could easily discern where a parti-

cular feature of the ground is in relation to the rest, or where a particular feature he would like to establish. This process is applicable to all land, small and large. It is applied to an area which covers only a few square yards, and also to that covers many square miles. It is used in house construction as well as in town planning. In laying out houses, the area-concerned-being limited, the application of the system is easy; but when square miles of area have to be considered, as in the case of town planning, visualisation becomes more difficult.

To reduce this difficulty, they appear to have superimposed another figure on the square. This new figure covers the entire area as the previous one, but it contains many concentric squares, smaller and smaller in area. From what is stated in Manasara, the number of the concentric or annular squares, including the outer one, is limited to four. But according to Manushyalaya Chandrika, the squares are extended to nine. The latter is for the purpose of house construction, while the former is for town planning. This system is called "Vithi Vidhanam", in Manushyalaya-Chandrika. In Manasara the system appears to have been brought in through the back door. Manasara states: "If the plan be of the Chandita type, the four plots in the centre are known as Brahma part: outside this, there should be twelve plots around, known as Daivika; beyond this twenty plots should be known as Manusha; outside this twenty-eight surrounding plots should be known as Paisacha." The total number of plots in Chandita squaring is 64, and if these plots are arranged and grouped as above, five concentric squares will be obtained, the space between each of the concentric or annular squares being called, from the extremity of the plot, Paisacha Vithi Manusha Vithi, Daivika Vithi, and the centre plot as Brahma Vithi.

Manasara further elaborates this kind of distribution for Paramasaika division of 81 squares and Standila division of 49 squares. And they are:—

	Paramasayika.	*Standila.*
Brahma Vithi	9 Squares.	1 Square.
Daivika „	16 „	8 „
Manusha „	24 „	16 „
Paisacha „	32 „	24 „

Here the names, given to the Vithis, have created confusion in the minds of later day writers, as they wrongly hold the opinion, that Brahma Vithi was for Brahmans, and Paisacha Vithi was for lowest castes, etc.

How the names of the squares after gods, as well as the superimposition of the Vithis, helped the Silpi in laying out towns,—is seen from Chapter IX.

Though the benefits, derived from "Vithi Vidhana" or laying out vithis, are not clear from Manasara; still one direction-given-is full of significance. Manasara states that "In the Paisacha (Vithi) there should be similarly made a street running through all the plots." This shows that Vithi Vidhan is for the purpose of laying down or locating streets, parallel to the Vithis through the middle or through their extremeties, for, in all rectangular lay-outs all streets and subsidiary lanes are parallel and perpendicular to each other. This opinion is further justified by directions like these:—"The houses of all kinds of work men should be on the high ways, etc.," The name Vithi, given to the division, is also significant in this respect, for, Vithi means a street or road.

The squaring system, once introduced as Survey, to facilitate planning and layout by the Silpis, has since been used for multi-

farious other purposes. The Brahmins use them for their daily pooja or worship; they use the division of the square into four equal squares for Ganapathi pooja, propeciatory rites for the elephant-headed god Ganapathi; sixty-four divided square, they use for Bhagavati (goddess) pooja. The sixty-four division square is also used for Chess-play. These and other diagrams are used for Thanthrikik rites, or rites enjoined under Tantras for the attainment of cherished objects. They are used for sorcery and witch-craft, not only by Brahmins, but even by the lowest castes as well. The reason for such use may be found in Vastu-bali. When the Silpis introduced sacrifice for gods in the respective squares, their object in view was a kind of memory training, or Pelmanism, and the worship of gods in the squares made others to imitate and adopt them for their peculiar form of worship; some worship with milk and honey, others with flowers and leaves. But the Silpis worshipped by sacrificing goats, fowls and birds. The sacrifice for the Vastu-rakshasa or Vastu-bali served the Silpis double purpose. First, it refreshed their memory in locating the gods; secondly, it gave them an opportunity for revelry and enjoyment. The critics of social habits and club life in India often miss the mark by their inability to recognise the importance of this and similar observances in relation to the social life of the people. Incidently the nature of worship and the articles of offering give an indication to the habits of the people in ancient days. Certainly, this practice existed long before the Hindus gave up alcohol and meat-eating, and at a time though the gods wore sacred thread like the Brahmins (see Manasara), the people were not very particular as to what sort of food they gave to their Brahmin or twice-born gods. Generally speaking, no man in

ancient days sacrificed anything which he did not eat as 'prasad' or sanctified food. Abraham gave his son as burnt offering to his god; but no human sacrifice is mentioned in connection with Vastu-bali, though there are rumours or stories of it often connected with it. Hindus gave up meat-eating on a large scale, most probably after the time of Asoka, though earlier form of prohibition is seen in Kautilya's Arthsastra and though no doubt, the Jains practised both tee-totalism and vegitarianism long before. Hindus appear to have been great meat-eaters and non-tee-totallers. Their Sastras and Puranas are full of their achievements in this respect. Even Darmaputra, the great king who was translated to Heaven without passing through the usual form of death, is supposed to have killed thousands of cows, buffalos, calves, fowls, etc., to celebrate the marriage of his nephew. Many of the great gods were reputed to be always in a state of intoxication. The great sage, Sukra, the great authority of Silpa Sastra and town planning, had his great weakness in drink. The cause of the quarrel between the Indo-Aryans and the Iranians is supposed to have been a question of drink. The Iranians believed only in light wines, but the Indo-Aryans were addicted to a very strong drink, called Soma, probably the ordinary Mowa liqour, which they drank after dedicating it to their gods; the Iranians did not believe in Soma, that was the causus belli for the war between them; rejecting the drink sanctified by the god was an insult to the whole race of the Hindus. It is not known whether the town planners of Mohenjo-daro were in the habit of drinking; but it is evident, they followed the system of squaring the field and the true orientation of the Silpis in laying out the then new town of Mohenjo-daro, sometime in the fourth Millennium B.C.

CHAPTER IV

Hindu Measurements

THE PRIMITIVE MAN, LIKE A CHILD, INDICATED THE SIZE BY hands and fingers. The Silpi-measuring system retains this tradition. 'Angula', the finger, and 'hasta', the hand, are still being used. The standardisation of these measuring units was done ages ago. The first attempt at the standardisation of the finger was made by selecting the middle finger; but on realising that the thickness of the middle fingers differed in individuals, they fixed its knuckle as the standard. Twelve of these were fixed as the measure of a span, and two spans made one hand. Still they found non-uniformity in knuckles, so they standardised the knuckle, by selecting fairly steady objects from nature. They found rice and Yava (barley) as suitable objects, and the combined thickness of eight of them, they fixed as one Angula or finger. Angula thus fixed was $\frac{3}{4}$ of an English inch. Therefore one Yava became $\frac{3}{32}$ of an inch. The silpis still required finer measurement; they looked for smaller objects in nature. Here they had to struggle very hard.

Kautilya's Artha-sastra, a book written in the fourth century B. C., gives the following table of measurements which can be taken as standard :—

8 Paramanavahs	=	1 Rethha-dhuli.
8 Rethha-dhuli	=	1 Liksha.
8 Likshas	=	1 Yuka.
8 Yukas	=	1 Yava.

8 Yavas	=	1 Angula.
12 Angulas	=	1 Vitasti.
2 Vitastis	=	1 Aratni. (or 1 Kol).

Aratni is the same as Manasara's kishku and the South Indian Kol. Kol literally means a stick, hence a measuring stick and the expression Kol is used here for brevity's sake. In some parts of the country Tila took the place of Yuka. Tila is Gingili or sesame seed; and the standard gingili seed was the fully ripe one, which was still in the pod, and the thickness of eight of these unborn gingili was a standard Yava. What is the actual significance of Liksha is uncertain, but it corresponds with the Rekha. Rekha is described as Bala-agra or the extreme thin end of a hair. One eighth of this is equal to a Ratha-dhuli, that is, a dust particle thrown up by the wheel of a chariot. This is also known as Renu. One-eighth of this is equal to one Paramanavah or Paramanu. It is stated that Paramanu can be seen only by the sages; still for an ordinary individual to have a conception of it, he may see it in the smallest dust particle which floats about in a beam of the sun's ray that enters through the tiniest slit into an otherwise dark room.

Whatever might have been the practical utility of such minute measurements, undoubtedly the Silpis had envisaged very minute divisions of their measuring rod. One Paramanu is equal to $\frac{1}{8 \times 64 \times 64}$ of one Angula or $\frac{3}{131072}$ of an Englich Inch. It is stated that the Standard of civilisation can be judged by the fineness of the measuring instrument which a nation used. If so, the Ancient Hindus had attained a very high degree in civilization. Had it not been for the Micrometers and other instruments of fineness, the development of high speed aero-engines would

have retarded. The Hindus never had such instruments, but the high standard of perfection they achieved in carving, where minute objects, wrought with remarkable accuracy, can easily be attributed to their measuring rod and its minute divisions. Alas the craftsmen in India appear to have forgotten how to use the finely conceived measuring rod devised by their ancestors. I was told that a craftsman attached to the court of an Indian Prince had produced the image of an elephant in ivory, small enough to be shut in the husk of a paddy : Thereupon I made a special journey to see this elephant with a view to learn the art and proportions used in its making. But on interviewing the Silpi I was shocked to learn that his craftsmanship consisted in the use of a proportional compass, though of his own make. He had no knowledge of the ancient Hindu proportions : from a large sized model of an elephant, he reduced the dimensions by the use of his proportionate compass. In India, it appears that there never was a central Government strong enough or keen enough, to introduce a general standard of measures or weights. Even the British Government have failed in this respect. In buying foreign articles, Indian merchants use the English Standard of weights and measures; but in local bazaars, they use the weights and measures of the respective locality. Kings, like Chandra Gupta Maurya, appear to have attempted at Standardization; but Chandra Gupta's Standardization, as done by Kautilya, appears to be a mere codification of the weights and measurements prevalent in those days. However, it is remarkable how some of the weights, measures, and coins, mentioned by Kautilya, are still in use in the remote parts on the Malabar coast, where, even now measurements of time, like "Nalika" and "Vinalika", measures of weights, like "Pala" and "Tula" and

coinage like "Panano", are still found, though these parts were never under the sway of the Mauryan kings. The Silpis in the South, standardised Angula by means of rice, which was obtained from a variety of paddy, known as 'njavara', a tough, hard and regularly shaped grain, rarely cultivated, but delicious as a diet.

The Silpa-sastras are most confusing when they speak of the recognised system of measurements. Some speak of Angulas as consisting of 6, 7 or 8 corns; while others attempt to standardise Angulas by 3, 3 and a half, and four paddies. This appears to have been through a desire to standardise Angula by means of the local materials The confusion, caused by these different units, became most confounded when kols of different length, varying from 24 to 31 Angulas were mentioned. The existence of numerous measures by gradual increment or decrease may have had some utility behind it, and it might also have been for the purpose of overcoming certain practical difficulties. Some of these seem to have had their origin in the material of the measuring rope, while others in the Slope of the ground to be measured. The standard measuring rod was 24 Angulas in length, or equal to 18 English Inches, though rods of twice the length was in actual use. But when large areas had to be measured, a field or forest for example, the ordinary measuring rod was most unsuitable and special measuring poles or ropes were used. Even now crude measuring rods are used in selling, buying or letting the land in many parts of the country. Kautilya's Arthasastra specifies different measuring rods for different purposes. They in ancient days used sounds like "Goruta" (the cry of a cow) and the resonant sound caused by the tensioned string of the bows. The latter might have been used in warfare and the former to locate the distance of cattle,

The ropes, used on the Malabar coast, were made of cocoanut fibre. Manasara speaks of ropes made of silk, cotton, "Kusa" grass and barks of "Ketaka" and Banyan trees, etc But it should be realised that the ropes, made of different materials, have different tensions, and they are also differently affected by temperature variations and other climatic conditions. The tension is due to the pull on the rope, the sag is due to the weight, and expansion or contraction is due to the temperature and humidity; all these will have to be taken into consideration in ascertaining accurate measurements. Even the measuring tape, made of case-hardened steel, is not entirely free from all these factors. It appears that the Ancient Silpis had some knowledge of these disturbing elements. If so, the apparent discrepancies in measuring units might be due to the difference in materials and conditions. A rope, made of grass, will certainly extend more than a rope, made of Coir, under the same pull; therefore, the measurements, taken by these ropes, will differ; the greater the tension, the greater the reading; the greater the sag, lesser the reading.

The Silpis introduced a system of measurements least affected by these factors, a proportionate one, which may be termed as "Tala" system. The tala system did not depend on any standard measurement, but it was based on the thing as a whole. The Tala system was used invariably in Sculpture and occasionally in Architecture.

In sculpture, an image,-whether it is of a man, animal or bird,-is conceived to be of so many talas or equal divisions. The Talas may be of any number; generally, for human figures, they used to be 8, 9, or 10. Each Tala is divided into 12 parts; consequently, a ten Tala figure will have 120 parts, from head to foot. The distance between the different parts of the body, the length,

breadth and thickness of the limbs, were all taken in the number of these divisions or parts, for instance in ten Tala system, for the image of a female.

Head, from crown to the hair on the forehead	4	parts.
Forehead up to the eye-line	5	,,
Nose up to the tip	4	,,
Nose tip to the chin	3½	,,
Neck joint	½	,,
Neck	4	,,
Length of thumb	4	,,
Length of fore-finger and ring finger	5½	,,
Length of the little finger	4	,,
Length of the middle finger	6	,,
Width of each breast	9½	,,
Height of breast	4½	,,
Distance between breasts	1	,,
Width of the mid-thigh	12	,,

and so on.

Hence, knowing beforehand the relative proportions between the different parts, you take any height, divide it into talas and parts, and start shaping the figure, limb by limb.

By the application of the Tala system, the Indians made gigantic figures of saints and demons in rock; and with equal ease, they made charms and ornaments in ivory and precious stones, with full details. Giants, in certain countries, have distorted or bulged out features, but in India, they have been gentlemen of huge proportions. The Tala system was used for making bird and animal forms; and also in the construction of the houses and shrines where the owner's or the diety's height was taken as one Tala.

Without the use of Tala system, it would have been impossible for them to build their magnificent rock cut temples. To cut the rock out in different storeys, plinths and other architectural details, they visualised them as a whole; often worked from the top downwards. Gigantic structures, Chaldean and Egyptian, were constructed from the bottom upwards, but the Hindu Silpis appear to have started some of their huge monolithic structures from the top, and worked down to the bottom, and the details filled in as they proceeded. It may not have been possible for them in many cases to have the dry bones of their structure first and embelish it afterwards. They had to conceive the whole scheme mentally without any plans or blueprints. The Hindu Silpis appear to have accomplished all these by their wonderful Tala system, and their series of proportions that will be given in chapter V.

Time was generally measured in "Nalika", as it is still being done in certain parts of India, notwithstanding the introduction of cronometers. The Hindu calendar is based on Nalika. One Nalika is equal to twenty-four minutes or two and a half Nalikas equal to one hour. Their table of time was:

60 Nimishas	=1 Vinalika.
60 Vinalikas	=1 Nalika.
60 Nalikas	=1 complete day.
further 30 Nalikas	=1 day or night.
2 Nalikas	=1 Muhurta.
7½ Nalikas	=1 Vyama.
4 Vyamas	=1 day or night.

This table is further extended as 30 days equal to a Lunar month, 15 days representing each phase of the Moon, and 60 days representing one Rtu and six Rtus equal to one year.

This, no doubt, is a sexagesimal system of reckoning. The sexagesimal system is reputed to be the method of the Ancient Chaldeans. But it being based on the observation of the Moon, might have originated in any country where the tropical nights and clear sky were visible. "All Nations", Sir Issac Newton says, "before the just length of the Solar year was known, reckoned month by the course of the Moon and years by the return of winter and summer, spring and autumn; and in making the calendar for their festivals they reckoned thirty days to a Lunar Month, and twelve lunar months to a year, taking the nearest round numbers, whence came the division of the ecliptic into 360 degrees."

Whether or not the Indians were influenced by other nations, what they appear to have done is this. They watched the different phases of the Moon increasing, decreasing, disappearing, and appearing again into full glory. When it appeared in full glory, they named it "Poorna-masi" or Poorna (Full) ma (Moon) asi (is); when it disappeared altogether, they named it "Amavasi", A-Ma-Asi or No-Moon-is. They divided the period between the Full Moon and No-Moon by days, dates, or Thithis. The word Thithi appears to have been derived from the Tamil "Thiyathi" which means date, hence Thithi is that which makes "Thiyathis" or dates. The fourteen days between the Full Moon and No Moons they named as:—

(1) Prathima or Pratipada, the first step of Ma or Moon, when the Moon was practically the "Prathima" or the image of the Moon, that is, of the previous night.

(2) Dvithiya, the second "Thiyathi" or date.

(3) Thrithiya, the third Thiyathi or date.

(4) Chathurthi, the fourth Thi or Thiyathi.

(5) Panchami, panch or the fifth Ma or Moon was.
(6) Shashti, or the sixth Ti or Thi or Thiyathi.
(7) Saptami, the seventh Moon.
(8) Ashtami, the eighth Moon.
(9) Navami, the ninth Moon.
(10) Dasami, the tenth Moon.
(11) Ekadasi, the eleventh.
(12) Dvadasi, the 12th.
(13) Thrayodasi, the thirteenth.
(14) Chathurdasi, the fourteenth.
(15) The fifteenth night was No-Moon night.

This cycle of fifteen they termed "Krishna Paksha" or the dark half of the month. Then on the sixteenth night when the Moon was slightly visible or practically as dark as on the previous night, they called it again Prathipada, and so on till Chathurdasi, and the fifteenth night as Full Moon again or Poorna Masi. The term Poorna-Masi itself, as it means (full) masa or full month, shows that it was the date on which the month was complete. Hence, in the far remote days in Hindu computation, the night was the first and the day after. But this scheme was changed when stellar computation was introduced, then the day started with the rising of the Nakshatras or constellation of certain stars in the eastern horizon at the Tamil Observatory at the Equator. This observatory could not have been in Sumatra or Borneo which the Indians conquered or colonised, for the colonization took place, probably thousands of years after the introduction of the Tamil Solar Calendar. Hence, this observatory might have been in some sunken part of Lanka or Ceylon.

These names, though they were started in mere numerical order, became in course of time proper names for the respective days.

Purnamasya and Amavasya were complete public holidays, and set apart for religious and spiritual practices. Then Ekadasi and Thrayodasi were special fasting days; while other days had also their merits or demertis, which were vital to the daily life of the people as they are even to-day. If this system of reckoning was alien in its origin and imported to India, for instance say from Chaldea, the religious and spiritual importance attached to these days will be very difficult to be explained, unless it is assumed that the prehistoric inhibitants of India were Chaldeans, an assumption which cannot be historically substantiated. A close contact between the Chaldeans and the ancient Hindus can be suggested as an alternative explanation; but it is more than doubtful whether the influence of such a nature as affects the daily life and well being of the Hindus, could have been effected by commercial contact or even by political control. Though the Indians now observe Sunday as a holiday, it has nc social or religious significance for the Hindus or Musalmans; even the long centuries of Mahomedan rule have not made the Hindus to keep a fast during the Ramzan.

When Lunar computation came to be in India, is not known. Certain Lunar days are mentioned in Rig Veda. The Lunar Table is given in Kautilya-Arthasastra. The Lunar computation played a vital part, as even to-day, in the daily life of the Hindus throughout India.

The samllest unit in Lunar calculation is Nimisha, which is equal to two-fifths of a second. How thev reckoned this unit mechanically is not known. But by the observation of the shadows, as well as the position of the stars in the sky, they had developed a wonderful system of reckoning time. A knowledge of these was considered to be one of the essential equipments

in education. It was not long ago, that every school boy on the Malabar coast learned "Ati-alava-Vakyam," a method of computing time from the shadow cast by oneself. The shadow was to be measured by one's own feet, and the balance, left over, by the breadth of the fingers. The time, corresponding to each measure, is given in the book of "Vakyam." The boys had to learn these by heart. The accuracy of the system was based on the assumption that the length of the shadow cast by a person bear a fixed relation to his feet and the breadth of the fingers. The system can be considered as good enough to judge the time approximately. A method of reckoning time from the shadows cast by gnomon, is given in Kautilya-Arthasastra. In this the duration of the day is given in terms of the measurements of the shadow; when the shadow is 8 "Purushas" in length, $\frac{1}{8}$th part of the day is finished, when the shadow is 6 "Purushas", $\frac{1}{14}$th of the day is over, and so on. To test the accuracy of this method, the exact length of the gnomon and the exact measure or equivalent of the Purusha are required; but they are not available from Kautilya's Arthasastra. Kautilya is supposed to have written this as a standard work, but he does not appear to have tested the accuracy of what he wrote. For instance, it is said in connection with the shadow-reckoning that "no shadow is cast by gnomon at mid-day in certain months. This statement cannot hold good for any place in India. It is true only in respect of some place directly under the Equator, probably at the long forgotten observatory of the Tamils on some island in the Indian Ocean. Was Kautilya quoting some Tamil text of a bygone day? If so, it shows that the true Indian culture began to deteriorate long before the Mauryan period.

Apart from the Thithi system, there have been other ways of

naming the days. They are by Nakshatras and by week days. The Nakshatras, after which the days are named, are twenty-seven in number. These Nakshatras or constellations of stars, mark the time during which the Moon makes its appearance from point to point in the Zodiac, which takes a little over 27 days and seven hours. The names (in Tamil) of these twenty-seven stars, as per Table 2, are:—

1. Aswathi	2. Bharani	3. Karthika.
4. Rohini	5. Makayiram.	6. Thiruvathira.
7. Punartham.	8. Pooyam	9. Ayilyam.
10. Makam.	11. Pooram.	12. Uttiram.
13. Attham.	14. Chithira.	15. Chothi.
16. Visakam.	17. Anizam.	18. Ketta.
19. Mulam.	20. Pooratam.	21. Uthratam.
22. Onam.	23. Avitam.	24. Chathayam.
25. Puroorittathi.	26. Utthiritathi.	27. Revethi.

The twenty-seven Nakshatras and the computation based on them are of daily use in South India. A person's birthday is reckoned on a cycle based on the stars. When a person is born, the Nakshatra in ascendence is observed as well as the month, and his age, year by year, is reckoned by the appearance of that Nakshatra in the month of his birth. The computation of the age by this process, will naturally be less than that by the calendar year; so when a boy is said to be of ten years, he will actually be less than ten years by about a month.

Some Hindus like the Malayalees, not only observe the birthday but also the "Pithru Kriya", or the ceremonial performance of the death anniversary on the undernoted Nakshatra day. There again the Nakshatra or the constellation in ascension at the time of the death, is noted, as well as the month; and the anniver-

sary is performed in the next and successive years in the same month when that Nakshatra is in ascension. If, as in some years, in the same month, the same Nakshatra may be in ascension on two days, then the celebration is done on the second date, if the maximum ascension of the Nakshatra on the first date is less than 6 Nalika or 2 hours 24 minutes. It is strange that the Hindus in the North, where the Aryan ascendency was at the highest, the death and birth are observed and celebrated, not by the Nakshatras, but by Thithis or phases of the moon.

A third way of reckoning days has been by means of vara or week days. The seven week days according to Tamils are:—

1.	Ngayar	Sunday.
2.	Thinkal	Monday.
3.	Chovva	Tuesday.
4.	Buddhan	Wednesday.
5.	Vyazam	Thursday.
6.	Velli	Friday.
7.	Sani.	Saturday.

Some decalare that the week days came to India from the West. This does not appear to be correct. The week days are after the seven Grahas of the Indian planetory system which form the basis of the Indian Astrological and Astronomical calculations. It may be noted that the term "Graha" is applicable to the stars and planets alike, and Sunday as the first day of the week, the Hindus observed long before the Ascension day of Christ. The Hindu week and Week days are as old as their Calendar. They are even older than Kali-Yuga (era) which dates back from 3102 B. C. It should be noted that there is no astral sign like those of the Thithhi or Nakshatra to indicate the Vara. Thithis are seen from the phases of the Moon, Nakshtras by the ascendency

of certain constellations in the horizon, but the Varas do not herald the appearance of any Graha or planet. The Vara-reckoning of the 28 days may look like the rounding up of the 27 and odd days of the Solar calendar. Though the Hindus speak of Nine Grahas, they have taken only seven for reckoning Varas; perhaps, an investigation into this may reveal the origin of Vara computation. However, the religious importance, given by the Hindus to certain Vara days, may set aside the probability of their importation from the foreign countries, like Egypt, Mesopotamia and Europe. Sunday is a special fasting day to propetiate the God Sun, Monday is special for the Moon, and Saturday to pacify the Saturn, &c.

It may legitimately be asked what the Silpis had to do with Nakshatra, Thithi and Vara as their preoccupation should be with the lineal measures; but it will be seen that all these terms come frequently in their calculations, and in selecting suitable measures for the construction. (see Chapter VI).

CHAPTER V

Hindu Proportions, or the Relation between Length and Breadth

THE RELATION BETWEEN LENGTH AND BREADTH SEEMS TO have received considerable attention among the Silpis in ancient India. Lengths and breadths to them were not mere incidental units, but were co-related factors based on perimeters. It seems, they had their eyes always on the perimeter. The buildings were not mentioned in terms of length and breadth, but in terms of perimeters.

Why was this preference for the perimeters? Was it a childish desire for brevity? Or was it the outcome of the peculiar system of their survey? However, there are points that can be cited in its favour. Any or all geometrical figures can be mentioned in perimeters; while, in lengths and breadths, the figures like triangles, elipses, hexagons, etc., cannot be defined. The check by perimeter is most useful even in these days of scientific instruments, for, any irregularity in laying out or in construction could be easily detected. Whatever may be the reasons which influenced the Silpis to give prominence to the perimeters, it will be seen that the perimeters played a very important part in their scheme.

Adequate attention to length, breadth and height is of extreme importance in design. Utility alone should not be the criterion. Health giving elements and æsthetic factors should be fully exploited. Ugly structures and thought-provoking

details are detrimental to the growth of æsthetic sense and correct outlook on life. The paramount duty of the Silpi or the architect, is to produce something noble and sublime, at the sight of which or by contact with it thoughts will be enobled and actions will be quickened through the right channels. The Hindu Silpis appear to have strived for this ideal, and probably with that object in view, they set out to fix the relation between length, breadth and height, which after all is the essence of beauty and utility. How far they have succeeded in this line, can be ascertained only by exhaustive investigation and experiments. Perhaps, a close study of their methods may be beneficial to us at the present time, when even most costly buildings, designed and constructed by eminent architects, are defective in acoustic, health and amenity values which appear to depend more on appropriate length, breadth, and height.

The Manasara Silpa-sastra gives elaborate and bewildering details about length, breadth and height. But for any scientific inference from them, one has to fall back on Silpa-Vignana-Samgraha and Manusyalaya-Chandrika, two books from the Malabar coast. Unfortunately in both, the relation between lengths and breadths is given in the most unscientific manner. It is stated thus :—

"Take half the perimeter, divide it by any number from 8 to 32, both inclusive; then take four parts of these for breadth, and the remainder for length."

At the very outset, the practice of taking all four parts for the breadth irrespective of the numbers with which half the perimeter is divided, may militate one's sense of proportion against it. But on scrutiny it will be seen that it is not so absurd as it looks; and the formula can be scientifically deduced.

It should be admitted that length and breadth can be expressed in terms of each other, without reference to any unit of measurement. Then length can be equal to breadth, or it can be equal to any multiple of breadth, or it can be equal to breadth plus a fraction thereof :—

Let. L be = length.
B = breadth and
P = perimeter ; then

applying the assumptions as above—

(1) L can be = B
(2) L „ „ $= B + \frac{1}{4} B$
(3) L „ „ $= B + \frac{2}{4} B$
(4) L „ „ $= B + \frac{3}{4} B$
(5) L „ „ $= B + \frac{4}{4} B$
(6) L „ „ $= B + \frac{5}{4} B$

. . . .

. . . .

(25) L can be $= B + \frac{24}{4}$ B, and so on

Take the condition (1) when $L = B$,

As $P = 2\ (L + B)$

$P = 2 \times 2B$

$\frac{1}{2} P = 2\ B$

$\therefore\ B = \frac{1}{2} \times \frac{1}{2} P = \frac{4}{8} \times \frac{1}{2} P$

and $L = \frac{4}{8} \times \frac{1}{2} P$; hence the formula holds good, as we have divided half the perimeter by 8 ; and four parts give the breadth and the remainder gives the length.

Take the condition (2) when $L = B + \frac{1}{4}$ B, and $B = B$,

$P = 2\ (L + B)$

$= 2\ (\frac{5}{4} B + B)$

$\therefore\ \frac{1}{2} P = \frac{9}{4} B$

$$\therefore\ B = (\tfrac{1}{2}P) \times (\tfrac{4}{9})$$
$$\text{and } L = (\tfrac{1}{2}P) \times (\tfrac{5}{9})$$

Here too, the values obtained for B and L are according to the formula, for B is four parts of half the perimeter divided by 9, and the remaining five parts stand for L.

Similarly, when the other values for L, as given in equation (3) to (25), are treated, it will be seen that the dividing figures are 10, 11, 12 . . . . 32, and four parts in each case give the value for B and the remainders give the value of L. From this it will be clear that the above general rule is not absurd and it must have been based on the assumption as shown above. It will be seen if the values of L in terms of B have been increased in any other haphazard fashion, the division would contain improper fractions, which would make the solutions complicated, without any appreciable advantage to the relation between length and breadth. The reasons for limiting the divisor at 32, is also apparent, as at 32, the ratio between B and L is 1:7. Though the rule covers the range of proportions from 1:1 to 1:7, the ancient Silpis did not approve of this entire field. The proportions, obtained by the divisions of half the perimeter by the numbers 11, 15, 19, 23, 27 and 31, are prohibited from using for any purpose. The use of numbers 8, 9 and 10 are said to be specially suited for the design of shrines, temples, audience rooms, pleasure halls and such like; while the use of numbers 12, 13, 14, 16, 18, 36, 21, 22, 24, 28, 29, 30 and 32 may be used in general for construction.

The use of those proportions can be traced in many parts of India, especially where the construction is least affected by the Western or Public Works Departmental practice. The

relation between length and breadth according to this rule may be formulated as follows :—

$$L = B + C_1 \; B,$$

where L = length.

B = breadth.

and $C_1 = \frac{1}{4}, \frac{2}{4}, \frac{3}{4} \;.\;\;.\; \frac{12}{4} \;\;.\;\;.\;\;.$ Series (I)

The reasonableness of this absurd looking formula made me investigate a solitary proportion which is given in Manushyalaya Chandrika. This proportion is given as an alternative for the former series and reads thus :—

" Divide half the perimeter by 11, three parts of this to be taken for breadth, and eight parts to be taken for the length."

Here $B = (\frac{1}{2}P) \times (\frac{3}{11})$

and $L = (\frac{1}{2}P) \times (\frac{8}{11})$

Working back from this, the value of L in terms of B can be obtained :—

As $B = (\frac{1}{2}P) \times \frac{3}{11}$, $\frac{11}{3}B = \frac{1}{2}P = L + B$

and $\frac{11}{3}B$ can be written as $(\frac{8}{3}B + B)$

$$L + B = \frac{8}{3}B + B$$

$$\therefore \quad L = \frac{8}{3}B = B + (\frac{5}{3})\;B$$

This made me to wonder whether there was in existence, some time or other, another series in which L had the following values :—

(1) $L = B + \frac{1}{3}B$

(2) $L = B + \frac{2}{3}B$

(3) $L = B + \frac{3}{3}\;B$, and so on

To establish the existence of such a series, concrete examples were necessary. A reference was made to certain measurements recorded in my Note book (without any special motive). On scrutiny, it was found that these proportions could be traced to Mohenjo-daro, Kausambi and Bhita. Mohenjo-daro, the site

of the prehistoric civilisation of India, extending beyond 3,500 B.C. needs no introduction. Both Kausambi and Bhita are yet practically unknown and unexplored sites, and they are within twenty mile - radius of Allahabad, the former on the left bank, and the latter on the right bank of the river Yamuna. The fortified town of Kausamambi, whose numerous earth bastions are still seen at the site, was established by a Kuru-pañchala king, named Udayana. According to Pargiter's computation, Kausambi may date from about 820 B.C. But the upper strata of the ruins appear to belong to the popular Buddhist period. At Bhita too, which ended in glory as a Buddhist Monastry, the upper layer appears to belong to a period of Buddhist decadence. At both places, the faulty orientation and inaccurate squaring are visible, probably caused by deterioration in craft due to Buddhist proselytism. However, some measurements have shown that they used proportions of the kind that I was investigating.

At Bhita :—

ft. inches.

Room (a) L=9 - 6
B=7 - 3

here $L = B + \frac{1}{3}B$,

allowing for slight irregularities in construction or resetting by the Archeological Department.

Room (b) L=15′ - 6″
B= 9′ - 6″

here practically $L = B + \frac{2}{3}B$.

At Kausambi :—

Room (a) L=6′ - 3″
B=4′ - 9″

here $L=B+\frac{1}{3}B$ approximately

Room (b) $L=12'-3\frac{1}{2}''$

$B=6'-3''$

here $L=B+2B$ approximately

At Mohenjo-daro :—

Example 1. The great bath, which Sir John Marshall says "what appears to have been part of a vast Hydro-pathic establishment and the most imposing of all the remains that unearthed there, has the overall measurement of 180 ft. long and 108 ft. broad."

$$\text{Here} \quad L=B+\tfrac{2}{3}B=108+\tfrac{2}{3}\times 108.$$
$$=108+72$$
$$=180$$

Example 2. The swimming pool itself, which is said to be some 39 ft. long and 23 ft. broad,

$$\text{Here} \quad L\ B+\tfrac{2}{3}B=23+\tfrac{2}{3}\times 23.$$
$$=38\tfrac{1}{3}\text{ ft.}$$

i.e., less by eight inches, which appears to be due to certain strengthening of the walls done during or after the course of construction.

Example 3. A solidly built structure of the Intermediate period at Mohenjo-daro, building XXX in H. R. Area (page 205 Sir John Marshall's Mohenjo-daro and Indus Civilization). This measures 75 feet in length and 36 to 39 feet in width. Here the length is nearly twice the breadth. King Solomon's Temple had length equal to twice the Breadth, like the ancient Hindu Temple at Guruvayoor, Malabar. The length, equal to twice the breadth, is considered by the Hindu Silpis as most auspicious ; while the Muslim standard in India, if one is to judge from the Mosques, is length equal to three times the width.

Hindu criterion for the temple and such like is a perfect square like that of the Taj-Mahal; but for general purpose, the proportion of the breadth to length varies from two to three.

It is not known how far this series had been taken by the ancient Silpis. However, it appears that it had been taken at least to the limit when $L=B+3\ B=B+\frac{9}{3}B$. If so, the formula for this may be written in Silpi fashion as follows :—

" Divide half the perimeter by any number from 6 to 15, both inclusive, take 3 parts for the breadth and the remainder for length. The series of proportions based on this may also be formulated as follows :—

$$L = B + c_2 B$$

where $L =$ Length

$B =$ Breadth

and c_2 may be $= \frac{1}{3}, \frac{2}{3}, \frac{3}{3}, \frac{8}{4} \quad . \quad . \quad . \quad . \quad \frac{9}{3}$ Series (II)

A third series may be formed by the Ishta Dirgha formula, which will be traced, innunciated and explained in Chapter VI. The relation between the length and the Perimeter according to this formula is :—

$$P = \frac{L \times 8 + C,}{3}$$

Where $P=$Perimeter.

$L=$Length

and $c=1, 3, 5,$ or 7

Note : All units and constants here should be taken in the Silpi measure Kol, as the formula is not independent of the scale.

Apparently this formula excludes breadth B, but it is not so, for, the usual formula for Perimeter : $P=2\ (B+L)$ is equally applicable here. Hence the transposition of L to the right of the equation will give

$L = \frac{3P - c}{8}$, and substituting $\frac{1}{2}$ (L+B) for P, will give

$L = 3B - c/2$, where c=1, 3, 5 or 7 . . . . Series (III)

The buildings, that conform to this series, are found on the Malabar coast in numbers; and this series, or something similar to it, appears to have been used in Mohenjo-daro and Harappa as well.

Example (1). A spacious room at Harappa situated along the south end of the trench (vide P. 189 Harappa by M. S. Wats). It measures 26 ft. 6″ by 9 ft. 10″. Here the proportion of the length to the breadth is neither according to the formula for series (I) nor series (II). So let us see whether it is in conformity with series (III). For the application of the formula, as has been pointed out, it is essential to use the proper Silpi units, where $\frac{3}{4}$ of an inch is equal to one Angula :—

$$L = 26' - 6'' = \frac{318 \times 4}{3 \times 24} = 17\tfrac{2}{3} \text{ Kols}$$

$$\text{and } B = 9' - 10'' = \frac{118 \times 4}{3 \times 24} = 6\tfrac{5}{9} \text{ Kols.}$$

Now when $L = 17\frac{2}{3}$ kols, by the application of the formula, the perimeter :—

$$P = \frac{L \times 8 + C}{3} = \frac{53 \times 8}{3 \times 3} + \tfrac{1}{3}C$$

$$\therefore\ L + B = \tfrac{1}{2}P = \frac{53 \times 8}{2 \times 3 \times 3} + \tfrac{1}{6}C = \tfrac{424}{18} + \tfrac{1}{6}C.$$

$$= 23\tfrac{5}{9} + \tfrac{1}{6}C.$$

Now suppose C=3,

then $L + B = 23\frac{5}{9} + \frac{1}{2} = 24\frac{1}{18}$ Kols.

But L $= 17\frac{2}{3}$ Kols.

Therefore B $= 6\frac{7}{18}$ Kols.

$= 6.38$ Kols.

But the actual value of B as measured $=6\frac{5}{9}=6.5$ Kols. showing a difference of .16 kol, whicn is equal to 3.98 Angulas or 2.9. inch. which may be considered as negligible excess probably caused by error or alteration in the course of construction.

Example (2). Room 54 in L Area at Mohenjo-daro which is 13′ 2″ long and 6′ 0″ wide.

$$L=13'\ 2''=\frac{158\times4}{3\times24}=\frac{158}{18}=8\tfrac{7}{9}\text{ kols.}$$

$$\text{and }B=6'\ 0''=\frac{6\times12\times4}{3\times24}=4\text{ kols.}$$

By the application of the formula

$$P=\frac{L\times8+C}{3}=\frac{158\times8}{3\times24}+\tfrac{1}{3}C.$$

If $C=7$

$$L+B=\tfrac{1}{2}P=11\ \tfrac{9}{27}+1\tfrac{1}{6}=12.87$$

$$L\quad=\quad=8.7777$$

$$\text{Therefore } B=\quad=4.092.$$

while the actual $B=4$, which is less than the calculated B by 0.092 Kol. or 2.2 Angulas or 1.6 Inches.

This is surprising as I started with the assumption that the Ishta Dirgha formula, which formed the basis of this series, was a later introduction in the Silpa-sastras.

It appears that there was still a fourth Series of proportions in ancient days. In Vastu-Vijnana-Sumgraha, four methods of determining the relation between lengths and breadths are mentioned; namely, (i) Gunamsa, (ii) Pada Sutra, (iii) Ishta Dirgha, and (iv) Pada Pankthi. No doubt, Series (I) represents method (i) and Series (III) represents method (iii). Series (II) may refer to methods (ii) or (iv). If one of these refers to Series (II), a series for method (iv)

is to be found. I have a strong suspicion that the series (IV) was something in the nature of :—

$$
\begin{aligned}
L &= B + \tfrac{1}{9}\,B \\
&= B + \tfrac{2}{9}\,B \\
&= B + \tfrac{3}{9}\,B \\
&= B + \tfrac{4}{9}\,B \text{ and so on.}
\end{aligned}
$$

The reason for the disappearance of this series may be found in the introduction of a new measuring rod, which the Silpis introduced probably in pre-Mohenjo-daro days. (See chapter VII : Tests for Measurements) The general disappnearance of series (II) probably was due to the introduction of series (III), for, it is a modification of series (II), with great restrictions, as the utilisation of series (III) has been limited between the ratios L : B = 2 : 1 to 1 : 3, see Table III.

The Silpis appear to have checked the results obtained by one method with those by others. Silpa-vijnana-sumgraha gives stress that the results, obtained by Method (i), should not vary much from those obtained from Series (III), in dealing with the designing of buildings.

From what has been stated above, it is obvious that whatever series of proportions the Silpis used, their perimeter, length and breadth were co-related to each other. Similar relationship they fixed further in all details of their building designs. Height, for them, was to bear a direct relation to breadth; it had to be a part less or more than the breadth, such as height equal to $\frac{1}{8}$ of the breadth more or $\frac{1}{8}$ less than the breadth, according to the objects of design. Then from the height they deduced the height of the plinth, the height of the secondary plinth, the height of the columns, the height and the breadth of doors and windows, and in fact, every detail of the design such as cornices,

entabulators, 'sikharas,' and every detail of the successive storeys, as everything was to bear a fixed relation to the breadth. Though these relations were fixed, the designer had great latitude, by which he could stamp his individuality on the design. Why were these elaborate arrangements and co-relationship? Was it a mere caprice on the part of the Silpis, or a desire at standardisation? Or was it the result of centuries of experimenting with proportions to bring the best effect, beauty, utility and aesthetic values. No conclusion can be made without vast research in the matter. Is it worth while spending time and labour in this direction? This question cannot be answered beforehand, until it is ascertained whether there will be any useful or usable element in it, to help us in the design and in the construction, for the perfection of which we are struggling in different ways. However, there is a vast field for research.

CHAPTER VI

The Perimeter and the "Yoni"

IN THE LAST CHAPTER IT WAS SHOWN HOW THF SILPIS DERIVED length and breadth from the perimeters. Here it will be discussed how they derived perimeter and breadth from the length. The length on this account was called Ishta-Dirgha. The term Ishta-Dirgha consists of two words, Ishta (as you like or any) and Dirgha (the length). Ishta-Dirgha means, therefore, the length according to one's own choice, or in the present day phraseology, it means any given length. The perimeter was to be obtained from the given length, by the application of a certain formula.

The formula, for deriving the perimeter from any given length may be stated as follows :—

Multiply the length by eight, add a constant and divide the whole by three, the result is the perimeter. The constant as such has been long forgotten. The Silpa-sastras and the Silpis consider the constants as ordained figures for different castes, Brahman, Kshatriya, Vaisya and Sudra. If the building is for a Brahmin, the constant should be one; if it is for a Kshatrya, it should be three; if it is for a Sudra, it should be five; and if it is for a Vaisya, it should be seven. If these figures were fixed according to caste superiority, it is strange that the down—trodden Sudra should get prominence over the Vaisya. Probably the practice was introduced when the Sudras of the land-owning class were superior to the Vaisyas of the mercantile caste, probably about eighth century B.C., before Manu-Srmithi was written.

The formula may be put in the following form :—

$$P = \frac{L \times 8 + C}{3} \quad \ldots \quad (1)$$

Where L = Length,

P = Perimeter,

C = a constant with varying values of 1, 3, 5, & 7

Or substituting the different values of the constant,

$$P_1 = \frac{L \times 8 + 1}{3} \quad \ldots \quad (a)$$

$$P_3 = \frac{L \times 8 + 3}{3} \quad \ldots \quad (b)$$

$$P_5 = \frac{L \times 8 + 5}{3} \quad \ldots \quad (c)$$

$$P_7 = \frac{L \times 8 + 7}{3} \quad \ldots \quad (d)$$

Where P_1, P_3, P_5, and P_7 are perimeters for the respective constants.

The derivation of the formula (I) is hidden in mystery. No book on Silpa-Sastra unravels the secret. The Manasara, the standard work on Silpa-Sastra, does not even mention the formula; it is given in certain books found on the Malabar coast.

The sum total of the information that can be collected from these books, may be set down as follows :—

(1) When the house is for a Brahman, it must be in "Dhwaja Yoni" and the number for Dhwaja is one. Dhwaja means flagstaff.

(2) When the house is for a Kshatrya, it must be in "Simha Yoni". Simha means the Lion, and the number must be three.

(3) When the house is for a Sudra, it must be in

" Vrisha Yoni " and the number must be five. Vrisha means the bull.

(4) When the house is for a Vaisya, it must be in "Gaja or Gana Yoni," and the number must be seven.

The lion and the bull attributed to the Kshstrya and Sudra respectively, are appropriate as the lion indicates the ruling quality of the Kshatrya, and the bull indicates the husbandry habits of a Sudra. In like manner; if Dhwaja were to indicate Brahman, it should not mean Flag-staff, the stick or Danda that is being carried about by Brahman boys, during their Brahamcharya, or initiation period; and Gana for the Vaisyas may indicate, their collecting habit of money or merchandise.

(5) The Brahman's House should be in the east, the Kshatrya's house in the south, the Sudra's house in the west, and the Vaisya's house in the north.

(6) There are four other Yonis. They are known as " Dhuma (smoke) Yoni " in the south-east; Kukkura Yoni in the south-west ; " Kaka (crow) yoni " in the north-east ; and " Khara (dog) Yoni " in the north-west. In these Yonis, no houses should be constructed, even the house intended for the corners. These names do not appear to have any significance as usual, except for identification. Perhaps, if there were four more recognised castes, then the names of those castes might have been given to these four additional Yonis of the four corners. The

evil consequences, attending on the use of these Yonis, are given out in books, as terror for the violation of the south-east Yoni, strife for the south-west Yoni, insecurity for the north-west Yoni, and loss of reputation for the north-east Yoni.

Now as there are 8 Yonis and four of them have been de-designated by constant numbers 1. 3. 5. and 7, the others may be designated in similar fashion, thus, as east is one, and south is three, the south-east may be taken as two ; as south is three and west is five, south-west may be taken as four; similarly, north-west may be six and north-east eight. In other words, Yonis are or can be counted 1, 2, 3, 4, 5, 6, 7, and 8 from the east to the north-east in order of the eight cardinal points in a clock-wise direction.

The effect of these Yoni figures in the formula for the perimeter is seen from the following examples. Let L be any given length=10 Kols.

Then :—

		Kols		Angulas.
P_1	=	27	-	0
P_2	=	27	-	8
P_3	=	27	-	16
P_4	=	28	-	0
P_5	=	28	-	8
P_6	=	28	-	16
P_7	=	29	-	0
P_8	=	29	-	8

Hence the effect of the Yoni figures is to increase the perimeter by 8 Angulas at a time. But what is the Yoni ? In Manu-

shyalaya-Chandrika, Yoni is said to be the life of a "Graha"; and from Manasara-Silpa-sastra, it is seen that Yoni is something pertaining to the breadth. Gṛha generally means house, but it is a narrow interpretation. Graha may mean anything that is framed or circumscribed. Also houses for different castes may mean structures with different caste names.

Yoni is a test, though it is not clear from the books whether it is a test for the number or measure. Here the difficulty of using the same numerals for counts and measures is obvious. According to Manasara Silpa-sastra, the breadth, the length and the height should be tested to give a suitable Yoni; while Manushyalaya-Chandrika gives this test only for the perimeter. The Manushyalaya-Chandrika-rule is given thus; "Multiply the perimeter by 3 and divide by 8, the remainder is Yoni." Take any perimeter, say, 3 kols. Then 3×3, divided by 8 gives the remainder 1, which is its Yoni. Now does the Yoni refer to a number or measure? If it refers to the number, the Yoni should be found only by dividing the number by 8, then the Yoni of the number 21 should be 5. Therefore, it will be clear that the Yoni does not refer to the number, and it refers to the measure. To what system of measurement? Of course, it should refer to the system of the Hindu measurement. It will also be seen that it refers only to the Kol measure and not to any other. Then take the perimeter, say, 8 kols. Here 8×3, divided by 8, leaves no remainder. Are we to take its Yoni as zero? No, its Yoni should be considered as 8 or 8th, for, Yoni pertains to measurement, and every measurement should have a Yoni; the zero Yoni can take place only when the measurement is zero. Hence the Silpis, who hold the view that no remainder should be considered as

the zero Yoni, are mistaken. Then what should be the Yoni of a measure like 2 Kols? Here the division of 2×3 by 8 does not materialise; therefore, what is there should be considered as the remainder, or the Yoni should be 6.

In Ishta-Dirgha formula, the Yonis, no doubt, are constants. But the constants in a formula are derived from a series of experiments, and the average of the results is taken as the constant. But in a matter of mere measurement, what can be the constant? Now there is a certain passage in Tanthra-Samuchaya, which may lead us to find the constituent of a Yoni. The author of the "Tantra-samuchaya" in giving directions for the designs of Prāsādas states as follows:

"The breadths of the Prāsādas are generally from 2 Kols, 18 Angulas with successive increment of 8 Angulas. The perimeters then will be in I Yoni and V Yoni alternately".

As the Prāsādas are of equal length and breadth, the respective breadths, perimeters, and Yonis of the successive prāsādas can be put down as follows:—When the breadth is 2 Kols, 18 Angulas, the perimeter is 11 Kols, and it is in I Yoni. When 8 Angulas are added to the above breadth, the next breadth is 3 Kols 2 Angulas and its perimeter is 12 Kols 8 Angulas, and it is in V Yoni, and so on. These relations of the Yoni to successive perimeters should be true even when 8 Angulas are deducted at each step. Consequently, at the last stage, when the breadth is 2 Angulas, the perimeter will be 8 Angulas and its Yoni will be I. Therefore, it can be safely stated that Yoni is a measure of 8 Angulas.

Let 8 Angulas be any given perimeter. Find its Yoni. By applying the rule for finding out Yonis, $8 \times 3 = 24$ and dividing it by 8, we get 3 as the Yoni, of eight Angulas; while

we have seen above that the Yoni of 8 Angulas is I. It is therefore evident, if the rule for finding out Yonis is correct, we have made an error in its application. If before the application of the rule, the 8 Angula perimeter is converted into equivalent number of Kols, the resultant Yoni will be I. Hence, it is clear that the measures in Angulas should be converted into Kols, before the application of the Yoni formula. Now, as we have found out the make up of the Yoni, the successive Yonis may be put down as follows :—

I	Yoni	=	8 Angulas	=	$\frac{1}{3}$	Kol
II	Yoni	=	2×8 ,,	=	$\frac{2}{3}$	,,
III	Yoni	=	3×8 ,,	=	1	,,
IV	Yoni	=	4×8 ,,	=	$\frac{4}{3}$	,,
V	Yoni	=	5×8 ,,	=	$\frac{5}{3}$	,,
VI	Yoni	=	6×8 ,,	=	$\frac{6}{3}$	,,
VII	Yoni	=	7×8 ,,	=	$\frac{7}{3}$	,,
VIII	Yoni	=	8×8 ,,	=	$\frac{8}{3}$	,,

Thus having ascertained what a Yoni is and its equivalent in Silpi measurement, the formula (I) may be rewritten as follows :—

For I Yoni, P_1 (in Kols) $= \frac{\text{L (in Kols)} \times 8}{3} + \frac{1}{3}$ Kol.

III Yoni P_3 ,, $= \frac{\text{L (in Kols)} \times 8}{3} + \frac{3}{3}$ Kol.

V Yoni P_5 ,, $= \frac{\text{L (in Kols)} \times 8}{3} + \frac{5}{3}$ Kol.

VII Yoni P_7 ,, $= \frac{\text{L (in Kols)} \times 8}{3} + \frac{7}{3}$ Kol.

This formula for the perimeters is significant in one respect : it does not contain the element of breadth. The ordinary formula for the perimeter is $P = 2\ (L + B)$. The breadth is completely omitted from the formula, and in its place additional length, by

varying constants are introduced. In equating this formula against the ordinary formula for the Perimeters, we have :—

$$\frac{L \times 8 + C}{3} = 2(L + B)$$

$$\begin{aligned} \text{or } (\tfrac{8}{3})\ L + \tfrac{1}{3}C &= 2\ L + 2\ B \\ \text{or } 2\ B &= 2(\tfrac{1}{3})L + (\tfrac{1}{3}C) \\ \text{or } B &= (\tfrac{1}{3})L + (\tfrac{1}{6}C). \end{aligned}$$

If the constant of Yoni factor is omitted from the formula, B becomes equal to $\frac{1}{3}$ L. Hence, this can be taken as one of the bases of the formula. A second basis can be seen, when the value of L is taken as Unity. When $L=1$, $P=2$ and $\frac{2}{3}$, or $\frac{8}{3}$. Now $\frac{8}{3}$ is the value of 8 Yonis combined or of one Yoni cycle, if such a term is permissible. When the Yoni constants are taken into consideration, the perimeters are :—

$$\begin{aligned} P_1 &= \tfrac{8}{3} \text{ Kol} + 1 \text{ Yoni } (= \tfrac{1}{3} \text{ Kol}). \\ P_3 &= \tfrac{8}{3}\ \text{,,} + 3 \text{ Yoni } (= \tfrac{3}{3} \text{ Kol}). \\ P_5 &= \tfrac{8}{3}\ \text{,,} + 5 \text{ Yoni } (= \tfrac{5}{3} \text{ Kol}). \\ P_7 &= \tfrac{8}{3}\ \text{,,} + 7 \text{ Yoni } (= \tfrac{7}{3} \text{ Kol}). \end{aligned}$$

Now let us suppose that the Silpis had not made any restrictions about the other Yoni constants 2, 4, 6 and 8 ; and let us include them as well in our scheme of investigation, without the fear of dire consequences. Then the successive perimeters will be as follows :—

Kols		Kols		Yonis
P_1	=	$\frac{8}{3}$	+	1
P_2	=	,,	+	2
P_3	=	,,	+	3
P_4	=	,,	+	4
P_5	=	,,	+	5
P_6	=	,,	+	6

Kols		Kols		Yonis
P_7	=	$\frac{8}{3}$	+	7
P_8	=	,,	+	8

If we take any more perimeters beyond this, it is evident that they will have values above 8 Yonis enhanced by one Yoni at a time; but the Silpis have specified that there are only 8 Yonis; and not 9, 10, 11, 12 and etc. Here 8/3 has become a constant, while Yoni is changing from perimeter per permimeter. Now 8/3 Kols is equal to 8×8 Angulas or 8 Yonis. Therefore, the perimeters below P, like P_1', P_2', P_3', P_4', P_5', P_6', P_7', and P_8' are Yonis 1, 2, 3, 4, 5, 6, 7, and 8 respectively. Consequently, the perimeter is Yoni itself, in this case; and there are 8 Yonis before the perimeter becomes 3 Kols.

This does induce me to put the values in a Graphical form. See Diagram (11). Let the rays oI, oII, oIII, oIV, oV, oVI, oVII, and oVIII be drawn from the centre o, making the angles between each ray or any two pairs and all the pairs equal to 45 degrees. On these rays mark o1, o2, o3, o4, o5, o6, o7, o8 and o9 equal to 1, 2, 3, 4, 5, 6, 7, 8, 9, and 9 Yonis respectively. The points 1, 2, 3, 4, 5, etc. may be joined to form a curve. This will be a spiral curve, an Archimedian Spiral. The length o8 on ray oVIII represents 8 Yonis or 2 Kols 16 Angulas, or the perimeter for the length of one Kol according to the Ishta-Dirgha Formula, when the Yoni constant is omitted, and o9 represents 9 Yonis or 3 Kols, the perimeter for the same length when the first Yoni constant of 1 Kol is added. In the length o9, o1 represents one Yoni which is the constant in the formula and o9 represents 9 Yonis. Therefore, Yoni is seen in a fresh light, as the starting point of an Archemedian spiral, and the second point on the ray oI, where the curve meets after

one round, gives the value of the perimeter on the same scale. If this curve is continued, as it can be extended to any length, o11 on the ray oIII gives the perimeter in the Third Yoni formula, of which o3 represents the yoni constant, and o11 represents the perimeter 3 Kols 16 Angulas. Similarly o13 represents the perimeter in the fifth Yoni, with o5 the constant and so on. Therefore, the yoni constants merely indicate the starting points of respective curves; while the ordinates at the points, where the curves finish a complete circuit, give the respective perimeters.

Then in drawing this diagram, if the ray oI is made to coincide with the East cardinal point, automatically the rays oII, oIII, oIV, oV, oVI, oVII and oVIII would coincide with the rest of the cardinal points, south-east, south, south-west, west, north-west, north and north-east and the points, where the spiral cuts the rays, give the respective yoni constants of the formula. Thus this diagram actually reveals the mystery attached to the "Dik-Yonis" and the Yoni constants. Though no such a diagram has been mentioned in any text, I connot but wonder whether the ancient Silpis had a similar diagram? Its existence cannot be doubted if one realises fully the way of the Silpis!

Diagram (12) is similar to diagram (11), but with more points of the curve marked, and the points marked are not in yoni units, but in usual measurement of Kols and Angulas. It will be seen that on the East ray 3 kols is the perimeter for 1 kol length, 5 kols-16 Angulas is the perimeter for 2 kols, 8 kols-8 Angulas is the perimeter for 3 kols length, and so on. These points also indicate the complete rounds the spiral makes in respect of the east ray, or the number of times the curve touches the ray. The first complete round shows the condition, when the

length is equal to one Kol; the second round completes when the length is equal to 2 kols, and so on. Similarly it will be seen, the repsective figures, marked on the south, west and west and north rays, indicate the perimeters in these yonis, and the number of times the curve crosses these rays indicate the respective lengths.

If the yonis had not been given a circular habitation, it would have been necessary for the Silpis to have more than 8 yonis, like 9, 10, 11, 12 . . . . . . yonis, as far as one could count, like any other linear measurement; but by this device any or every perimeter is located by means of the yonis, as the dial on a clock indicates the time of the day for every day of the year or any year by the transit of the indicator over certain marks on the dial. In other words, by the yoni system, the Silpis have given, for the linear measurements, a direction and location, from where one can pick them up, to see whether they are suitable to one's purpose and reject or accept as the case may be. It should be remembered that the direction of a thing has been as important to man, as how many, how long ago, and how far.

An explanation for the rejection of the corner yonis can now be ventured from an examination of this diagram. The corner yonis contain all the perimeters which when converted into yonis, contain even yonis, while the others contain all odd yonis. By rejecting the corner yonis, the Silpis have been rejecting the even yonis; and by accepting the East, West, North and South directions, they were accepting only the odd yonis. Perhaps, they found that the odd yonis measurements were more pliable, easier for manipulation, more suited for lay-out, and adaptable for construction. The suitable yonis had to be remembered, and they might have thought that the best way to re-

member them was by associating them with the four well known classification of their days, the four castes; most probably when they introduced the names, there might not have been more than four castes in Indian polity. This might then have happened long before the four sub-divisions of castes assumed the present order of priority. When was this? It is for the historians to decide. However, let us hope now that the Sudra would be free to have a house constructed in Brahmana Yoni, without the fear of divine displeasure, and the Brahman would think what a fool he was in denying himself the privileges of the Sudra Yoni.

By the yoni system, the innumerable perimeters have been classified, docketed and located, and to avoid confusion, introduced simplicity by selecting certain of them as most suited for use and rejecting others as useless. The intrinsic merit of this arrange ment may be questioned, but the simplicity of the process cannot but be appreciated. If simplicity can be achieved, without the loss of accuracy, the process of design will lose most of its drudgery. Is it not for this reason that the standards have been introduced, say, even in case of manufactured articles, to see which one is to accept, and to ignore even the existence of which is to be rejected? In the British standard specifications, joists of certain dimensions are specified, but it does not show that there cannot be joists of other dimensions or that they cannot be used. But the use, of such, would increase the labour of both the designer and the manufacturer, and also would increase the cost of prdüction. In adopting anything, which is not specified and standardised, the user is looking for trouble. Hence the significance of the prohibited yoni perimeters, with the evil consequences of fear, loss of reputation, failure, etc.

By means of this diagram, a suitable perimeter for any of the the four classes of houses or structures can easily be determined at a glance; the length for the selected perimeter can also be ascer-certained by counting the revolutions made by the spiral at any selected ordinate and the breadth too can be ascertained with a true understanding of the relation between the length and the breath in respective yonis. By the application of the formula, it could be seen that when $L = 1$, the breadth in the 1st yoni, is one yoni and a half and when the length is 2 kols, the breadth is $2\frac{1}{2}$ yonis, and so on, always giving the breadth in number of yonis, by half yoni more than the length in number of Kols. In the III yoni, the breadth in yoni units is always $1\frac{1}{2}$ yonis more than the number of Kols in length. When the length is 3 Kols, the breadth is $4\frac{1}{2}$ yonis, and so on. In the V yoni, the breadth in yonis is $2\frac{1}{2}$ yonis more than the number of Kols in length; and in VII yoni, the breadth in yoni is $3\frac{1}{2}$ yonis more than the number of Kols in length. Did the ancient Silpis make this diagram in metallic plates and keep it as a ready reckoner in sacred temples?

The proportion between the lengths and the breadths that is obtained by the application of the four variations of this formula, is very interesting to note. L : B for different values of L, in respect of different yonis, is given in Table III, page 94.

TABLE III

Length	I Yoni	III Yoni	V Yoni	VII Yoni
L	L : B	L : B	L : B	L : B
1	2 : 1	1.2 : 1	0.85 : 1	0.66 : 1
2	2.40 : 1			
3	2.57 : 1			
4	2.66 : 1			
5	2.72 : 1			
6	2.76 : 1			
7	2.80 : 1			
8	2.82 : 1			
9	2.84 : 1			
10	2.85 : 1	2.6 : 1	2.4 : 1	2.22 : 1
20	2.92 : 1			
30	2.95 : 1	2.85 : 1	2.76 : 1	2.68 : 1
40				
50		2.91 : 1	2.85 : 1	2.80 : 1
100	2.985 : 1	2.95 : 1	2.92 : 1	2.89 : 1
1000		2.995 : 1	2.992 : 1	2.98 : 1
10,000		2.998 : 1	2.999 : 1	2.998 : 1
100,000				
1,000,000	2.99 : 1	2.999 : 1	2.9999 : 1	2.99998 : 1

From this Table, it will be seen that though the proportions between lengths and breadths have substantially varying values when the value of length is unity, they become practically the same for higher values of the length. When the length is unity, the proportion varies from 2 : 1 to 0.66; and when the value of L is 1,000, nay even 100, the proportions between the lengths and the breadths are practically the same, that is, in the neighbourhood of 2.9 : 1. Much wider range exists in the sphere of measurements below 30. Does it not show that the effective application of the formula was to deal with smaller figures or with smaller objects of design in some satisfactory way? Perhaps, it is so in view of the following details given in some books about the application of the formulae, or the use of the different constants, in addition to the four classes of grahas, mentioned above.

It is said that the value of C = 1, is to be used in cases of sheds for horses and cows; and in the design of banners, umbrellas, vessels, utensils, clothes, jewellery, platforms, boats, palanquins, chariots and all other vehicles for travelling. The value of C = 3, is to be used in the design of stools, chairs, thrones and other articles for sitting. The value of C = 5, is to be used in the design of sheds for camels and donkeys, utensils used for eating, drinking, cooking, clothes of certain descriptions, boxes, wells, tanks, and etc. The value of C = 7, is to be used in the design of cots, swinging beds, and other articles used for resting or sleeping. In these directions, there seems to be a great deal of confusion, the authors do not seem to be specific, and they differ greately.

A reference to the table of measurements, page 55-56, Chapter IV, will show that eight and multiples of eight were

the bases of the Silpi measurements : 8 Yukas make one Yava, 8 Yavas make one Angula, and 3 times 8 Angulas make one Kol. It has been shown that 8 Angulas were equal to one Yoni. Therefore, one Kol is equal to 3 Yonis. But in the scale of their measurement, they did not stop at the Kol, (their old measuring rod); on the other hand, they continued the multiple of the 8 further more and took eight times eight Yonis. It is not known what name they had given to eight times eight Yonis. Perhaps, they had no occasion for it, for, by taking these Yonis round the eight cardinal points, they have given Yoni measure a spiral existence, which could be extended to any limit, to infinity, while giving each Yoni a direction as well as a location. Thus it is clear that Yoni was a new unit which they introduced in their time-old measuring Rod. When was this introduced ? It is not known ; but it is sure that they introduced this before they evaluated the value of root two (see Chapter IX).

Interpolation or improvement in measurement is not uncommon. Even now a wider application of the decimal system in coinage and measure is under contemplation. Why ? In decimals, counting can be done quicker, and thereby time and labour saved. It seems that the object of the Silpis in introducing the Yoni system was also similar. With the introduction of Sunya (or Zero) and place-value in notation, the decimal system was at their feet ; still they did not adopt it. Why did the world have to wait till 1586 A.D., for Stevinus, a ware-house clerk in Holland, to introduce it ? The Silpi's aversion to the decimals might even be due to its inherent nature, or certain defects in the system. The decimal system is excellent in counting, or most adapted for the calculation board. The Hindus took advantage of it in their astronomical and mathematical calculations. Every astrologer

and astronomer in India, who makes his own calculation, uses the decimal and place-value notation. The calculations are not done on paper, but on a board or any flat surface by placing cowries of different shapes at different places in different groups and changing them over from place to place as warranted by the circumstances. The place-value notation is done by keeping groups of nine cowries at different places. The Sunya or zero is indicated by a special kind of cowrie known as "Bhadra" which is circular in shape and slightly spherical. It appears that it was from the shape of the Bhadra cowrie that "Sunya" or Arab Zipphér or European Cypher has taken its shape. I have seen that complicated problems in Binomial theorems being done by means of the cowrie computation, and results obtained in shorter time when compared to the present day process of calculation, but with equal accuracy. Still the Silpis did not use the decimal system without reservation as its utility for measuring was not good, for, it choked off and left little for the fineness of the instrument as Professor Lancelot Hogben says. By introducing the Yoni system, the Silpis kept the old system of eights, without radical change in their table of measurement. Most probably, it is due to this that the life history of the Yoni system was forgotten; but Yoni system has never been superseded. The introduction of the Yoni measure paved the way for the Ishta-Dirgha formula. From the Ishta-Dirgha formula, ... two more formulae can be deduced by transposition and substitution

As $P = \dfrac{L \times 8 + C}{3}$

$3P = L \times 8 + C$

or $8L = 3P - C$

or $L = \dfrac{3P - C}{8}$ . . . . Formula II.

Now, as it is well known that $P = 2(L + B)$ where B = breadth, by substituting this value of P in Formula II.

$$L = \frac{3P - C}{8} = \frac{3 \times 2(L+B) - C}{8}$$

$$= \frac{6L + 6B - C}{8}$$

$$\therefore 8L = 6L + 6B - C$$

$$\therefore 2L = 6B - \frac{C}{4}$$

$$\therefore L = 3B - \frac{C}{2} \quad \ldots \text{Formula III}$$

It is surprising that Manasara Silpa-Sastra does not give the Ishta-Dirgha formula. Perhaps the author or the transcribeder was not aware of it. The date of the Manasara Silpa-sastra is stated to be between 500 and 700 A.D., though Dr. P. K. Acharya is of opinion that it is a few centuries earlier or later than Vitruvius's Treatise on Architecture to which it bears some resemblance. The date of Vitruvius's Treatise is about 25 B.C. The Manasara gives evidence to the forgetfu ness of the formula, and the significance of the Yoni which is the quintessence of the formula. By the time of the Manasara the Yonis which were once mathematical or constructional units appear to have become associated with another Yoni, the female organ. The proof of this will be self-evident from the names given in the Manasara for the eight Yonis. The Manasara names the eight Yonis as the mare, she-buffalo, lioness, bitch, cow, she-donkey, she-elephant, and she-crow; all are females. Some of them were stated to be auspicious, while others inauspicious. The auspicious ones were the mare, the lioness, the cow and the she-elephant; and the rest inauspicious. It will be noticed that the counter parts of the last three of them are the male animals attributed to the Yonis

in South Indian books. But the Manasara does not indicate any direction for these females, neither it gives any cardinal or ordinal numbers to them. Evidently when the Manasara was written the use and significance of the Yonis were long forgotten. It cannot but be admitted that the Manasara contained a good many very ancient practices and principles of the Hindu-Silpa Sastras, but that is no reason to antidate the book to great antiquity. In the opening paragragraph of the book it is stated that the science of architecture was enunciated by the Sages Siva, Brahma, Vishnu, Indra, Brihaspati, and Narada, and was elaborated by the Sage Manasara having made the subject matter even more than compltete." This shows that the sage Manasara is not the author of the book that has come to us as the Manasara Silpa-Sastra, unless, he had been advertising himself, a quality which was most repugnant to the wise men of India. Manasara gives details about the constructions of the Buddhist temples and images. From that we are not to conclude that the whole book was written after the introduction of the Buddha's images in the temples, which may have taken place about the 3rd or fourth century A.D. Manasara deals with practices old and new, both Buddhist and pre-Buddistic. Acoording to Manasara, in the earlier system of Town-planing the abode of the Buddhist sages or monks was with the dead body burners in the burial ground away from the Town, while in later planing they and their followers were given a separate zone in the South-West corner of the town.

CHAPTER VIII

Tests for Measurements

ALL THE WORLD OVER, IN OLDEN DAYS, THE PHILOSOPHERS had given a great deal of attention to the virtue and power of figures, but the s lpis in India seem to have given more attention to the practical side of the figures as they were used in measurement. The figures are used in dual capacity, the same number for counts and measurements. "The dual use of numbers for counts and estimate," says, Lancelot Hogben, "has been the source of continual misunderstanding between the practical man and the mathematician . . . ; when confronted with the difficulty of making whole numbers fit measurements, which imperfect human beings, using imperfect sense organs, with imperfect instruments, in an imperfect and changing world, the practical man was long content to go on adding fresh divisions to his scale of measurement." The practical man's chief interest in figures consisted of (1) to obtain suitable measurement for his construction, and (11) to have suitable divisions to his scale of measurement. "The right sort of figures," again to quote Professor Lancelot Hogben, "are built up like series which go on as far as you like." The figures that choke off are not suited for measurement. The figures like 1. 2, 1. 3, 1. 5, etc. are better than figures like 1, 2, 3, ... but they also choke off, after the tenth division hence they are not so suited like the figures, 1.333333333 . . or 1.666666666 . .

that do not choke off. The measurement that does not choke off can be taken to any extent, limitted only by the accuracy of the instrument one possesses. π with the value of 3.14159 . . is a figure of this kind, it can be utilised to any extent, provided our instruments are capable of dealing with it. The rustic carpenter who makes the country cart-wheel, uses the value of π only to the extent of 3.0, while the up-to-date Aero-Engineers use it to the extent of 3.1415. The ancient Silpis, in India, seem to have realised this quality of figures, if not, it is not possible to explain why they did not put into practice the decimal system, which was at their feet after the introduction of the Zero and place value notation.

The difficulties experienced by the ancient Silpis, cannot be appreciated fully, in our age of scientific advancement and accurate mathematical instruments. They had their difficulties, as the present age has its own. The introduction of figures like(—1) and $e = 2.71828$ helped us to counter-act some of the recent difficulties ; with the advancement of mathematics, more factors like these may be introduced. In a similar manner the ancient Silpis introduced several factors in their measurement, the full details of which have not come to us. Unfortunately we have only a few skeletons from which to build up the body.

A closer scrutiny of the perimeters obtained by the use of the Ishta-Dirgha Formula will show that one of the objects achieved was to get perimeters that do not choke off. When length is 1, its I Yoni perimeter is 3 or 2.999999999 . . . . . , its III Yoni perimeter is 3.666666666, V Yoni perimeter is 4.333333333, while VII Yoni perimeter is 5 or 4.999999999 . . . . The perimeters, thus obtained by the application of the Ishta-Dirgha formula, according to Malabar practice, were

put to a series of rigid tests. These tests may be stated as follows :—

(a) Aya—Vyaya Test

(b) Vara—Nakshatra Test.

(c) Age Test.

(d) Vara—Thithhi Test.

Aya is to be found by multiplying the perimeter by 8 and dividing the product by 12, the remainder that is left over is Aya. Vyaya is found by multiplying the perimeter by 3 and dividing the product by 14, the remainder left over is Vyaya. The Aya should be greater than Vyaya, then only the perimeter is to be accepted, that is, no perimeter whose Aya is less than Vyaya should be accepted. No satisfactory reason for this acceptance or rejection is given by any authors, or Silpis. The only explanation, that is offered is based on a plagiarism on these words. Aya means income, Vyaya means expense; income should be greater than expense, then only, there will be prosperity. Even Maya Matha does not give any further information, Maya Matha refers to Aya as "Varavu" and Vyaya as "Chelavu," both these Tamil words respectively mean income and expenditure.

The next test is to find Vara and Nakshatra, and to see whether the combination of the Vara and Nakshatra gives a suitable "Yoga." Vara is the week day, the seven days of the week beginning with Sunday; and there are 27 Nakshatras beginning from Aswathi see Page 66 Chapter III. To find the Vara or the Week Day, multiply the perimeter by 8 and divide by 27, the remainder is the day of the week. Multiply the perimeter by 8 and divide the product by 27, what is left over is Nakshatra. When comparing the Week Days with the Nakshatras,

it should give an acceptble Yoga or combination, then only the perimeter should be accepted.

Vayas or Age is a by-product from finding the Nakshatras; for when the perimeter is multiplied by 8 and divided by 27, the quotient obtained is the Age. When the quotient is one, the Age is Balya or child-hood, when it is two the age is Kaumara or Youth; when the quotient is three, it is Yauvana or Middle age; when it is four, it is Vardhkya or old age; and when it is five, it is Marana or death. Of these five ages or stages Youvana or middle age is "Uttama" or the best; Kaumara or the youth is "Madhyama" or indifferent; Vardhakya old age, and Balya, child hood, are "Adhama" or bad; while "Marana" or death is Nindya or not to be looked at. What peculiar things are these to judge measurements with? Another test is Thithi-Vara test. Thithi is found by multiplyng the perimeter by 8 and dividing by 30, the remainder is Thithhi. If the remainder is 1, it is the Prathi-pada of the Krishna-Paksha, or the first day after the Full-moon night. If the remainder is 13 it is New-moon. If the remainder is from 16 to 30, it represents the fifteen days of the Sukla Paksha, or the period of the bright Moon. These Thithhis are to be compared with the Varas or Week-days. In this comparison too there are some auspicious Yogas, or combination of certain specified vara with Thithhi to be obtained. One would imagine this is getting more and more into Superstition. Neither the Silpa-sastras, nor the Silpis who religiously follow these tests can give any satisfactory explanation to these.

These series of tests have been a chief source of redicule against Silpis and Silpa-sastras. Many investigators after laborious attempts, have turned them down as rank superstition,

Even the orthodox Hindu Scholars, who are not influenced by western ideas, have repeatedly characterised these tests as ab urd. Is it really as bad as all that?

Any investigation into the characteristics of Aya and Vyaya becomes more complicated on account of their multiplicity. What is given above is only one form of Aya and Vyaya, which may be written as:—

Aya from $\frac{P \times 8}{12}$, and

Vyaya from $\frac{P \times 3}{14}$, Where $P =$ the perimeter.

The comparison between this form of Aya and Vyaya is found only in books from the Malabar coast. But they admit also the existence of other forms of Ayayas and Vyayas. The prominent among those Vyayas are the remainders obtained by multiplying the perimeter P by 9 and dividing the product by 10.

Now the question arises whether the two kinds of Vyaya, as mentioned above can be compared with the same Ayas from P multiplied by 8 and divided by 12. Silpa sastras do not say anything about this point, but the Silpis seem to think that both forms can be used indiscriminately. The difficulty will be apparent from the examination of a certain number of respective Ayas and Vyayas as are given in Table IV.

TABLE IV

Length	Perimeter	Aya :Px8 / 12	Vyaya :Px9 / 10	Remarks	Vyaya :Px3 / 14	Remarks.
	Kol-Ang	Kol-Ang	Kol-Ang	Remarks	Kol-Ang	Remarks
1	3-0	12-0	7-0	Aya Greater.	9-0	Aya Greater
2	5-16	9-8	1-0	Aya Greater.	3-0	Aya greater.
3	8-8	6-16	5-0	Aya Greater.	11-0	Aya less
4	11-0	4-0	9-0	Aya less	5-0	Aya less
5	13-16	1-8	3-0	Aya less	13-0	Aya less
6	16-8	10-16	7-0	Aya Greater.	7-0	Aya greater.
7	19-0	8-0	1-0	Aya Greater.	1-0	Aya greater.
8	21-16	5-8	5- 0	Aya greater.	9-0	Aya less.
9	24-8	2-16	9- 0	Ayaless	3-0	Aya less
10	27-0	12-0	3- 0	Aya greater.	11-0	Aya greater.

In the given ten examples, in all except two, both the kind of Vyayas follow the same order, that is, if one kind of Vyaya is less, the other kind is also less, or if one kind of Vyaya is greater the other kind is also greater; the two exceptions are No. 3 and No. 8 where the above uniformity does not hold good.

Still the Silpa Sastras are silent on this point. When the books found on the Malabar Coast are silent about the significance of the Aya-Vyaya test, a reference to the famous Manasara Silps-sastra may strike the investigator as the best thing to do. But he is bound to meet with greater disappointment there. For Manasara does not give the kind of Vyaya derived from multiplying P by 3 and dividing by 14, and in fact deals with the Ayas and Vyayas on different basis. According to Manasara:—

Aya is the remainder from $\frac{L \times 8}{12}$ and

Vyaya is the remainder from $\frac{B \times 9}{10}$

where L = length

and B = breadth

On another occasion it is stated that Aya can be the remainder of the breadth multiplied by 6, 7, or 8 and divided by 12, while Vyaya can be the remainder of the breadth multiplied by 7, 8 or 9 and divided by 10. Probably this may have been the case where the length and breadth were the same.

When Aya is only in respect of Length and Vayaya is in respect of breadth, to find suitable lengths and breadths appears to be easier, for adjustments in lengths and breadths can be made to get the Aya greater than Vyaya. The Manasara gives directions how to accomplish this. Divide the inauspicious Aya into 30 parts and add one part to make it auspicious. How-

ever, the practice of finding suitable measures from the perimeter appears to be an improvement on the former.

By applying the analogy of Yoni and the Yoni cycle, we get:—

(1) For Aya $\frac{P \times 8}{12} = \frac{P}{\frac{12}{8}}$ where the Aya cycle is $\frac{12}{8}$ Kols and as there are 12 Ayas, each Aya is equal to $\frac{1}{8}$ Kol or 3 Angulas.

(2) For Vyaya $\frac{P \times 3}{14} = \frac{P}{\frac{14}{3}}$ where Vyaya cycle is $\frac{14}{3}$ or $4\frac{2}{3}$ Kols and as there are 14 Vyayas in this group, each Vyaya is equal to $4\frac{1}{3}$ Kols or 8 Angulas.

(3) For Vyaya $\frac{P \times 9}{10} = \frac{P}{\frac{10}{9}}$, where Vyaya cycle is equal to $\frac{10}{9}$ Kol and as there are 10 Vyayas in this group, each Vyaya is equal to $\frac{1}{9}$ Kol or $2\frac{2}{3}$ Angulas.

From this it is clear that Aya-Vyaya comparison is made between the fraction of Kols left over after the process of respective divisions, without taking notice of the quotients or their magnitude. It will also be apparent from the way the Ayas and Vyayas are given or expressed in Kols and Angulas, as is seen from the Table I as is usual with the Silpis, they were using a deo-decimal system, based on their units of measurement, just with equal facility, as we use the deodecimal system based on the English units. Here they avoided expressing Kols in fractions. Although the fractions were put in their deo-decimal forms, it was the three Angula bits of the Aya that were being compared to eight-Angula bits of one kind of Vyaya and the two and two-third Angula-bits of another kind of Vyaya. The comparison between the three-angula bits and two and two third angula bits, or comparison between $\frac{1}{8}$ Kol and $\frac{1}{9}$ Kol appears to have been the

general practice among the Silpis, but the Malayalee Silpis in comparing three angula bits with eight angula bits appear to have tipped over. Was it possible they had another Aya to be compared with this Vyaya ?

In Manushyalaya Chandrika an alternative way of finding Aya is mentioned. The rule is given thus :—

" Add one third of the perimeter to the perimeter, multiply by two and divine by eight, the remainder is Aya."

$\frac{2(P+\frac{1}{3}P)}{8} = \frac{P}{3} = P \times \frac{1}{3}$, while the other kind of Aya $\frac{P \times 8}{12} = P \times \frac{2}{3}$, showing that the division in this alternative system is double that of the other. But from the formula it appears that there are eight Ayas of this group and each Aya is equal to $\frac{3}{8}$ of a kol or 9-Angulas. Thus there are two kinds of Ayas, one of three angula bits and the other of 9 Angula bits, against one Vyaya of two and two third angula bits and another Vyaya of nine angula bits. Hence it can be safely assumed that the correct comparison should be between three angula Aya and-two-and-two-third angula Vyaya on the one hand and between nine angula Aya and eight angula Vyaya on the other. If so the Malabar practice is incorrect, unless there are other factors, which counteract the mistake.

Having come to the conclusion that the Aya from $\frac{P \times 8}{12}$ should be compared with Vyaya from $\frac{P \times 9}{10}$ let us study their characteristics further. Here in case of Aya P is divided by $\frac{12}{8}$ or $\frac{3}{2}$; and in the case of Vyaya P is divided by $\frac{10}{9}$. Now $\frac{3}{2}$ represents the limiting value of a geometrical series :—

$$1 + \frac{1}{3} + \frac{1}{3^2} + \frac{1}{3^3} \ldots\ldots\ldots \infty = 1 + \frac{1}{3-1} = 1\tfrac{1}{2} = \frac{3}{2}$$

Again $\frac{10}{9}$ represents the limiting value of another geometrical series

$$1 + \frac{1}{10} + \frac{1}{10^2} + \frac{1}{10^3} \cdots\cdots\cdots \propto = 1 + \frac{1}{10-1} = \frac{10}{9}$$

It is evident that for some unexplained reasons they are testing their perimeters, with these two standards to find their suitability for use in construction. To see the effects of the application of these tests for the perimeters, take any perimeter,

P = 5 Kols 12 Angulas ; Aya = $\dot{7}$, and Vyaya = ·1

P = 7 Kols 0 Angulas, Aya = $\dot{6}$, and Vyaya = ·3

Thus in every case Aya fraction is a recurring decimal, while the Vyaya fraction is a non-recurring decimal. When it is said that Aya should be gre ter than Vyaya, what in effect is that the recurring decimal should be gre ter than the corresponding non-recurring decimal. By Aya process, what is being achieved is conversion of the usual measure into a never ending fraction ; 5 kols 12 Angulas become 3. 777777777 . . . and 7 kols become 4.666666666 . . . .

Now the never ending fractions like these are good, but their utilisation would depend on the accuracy of the instrument one possesses. What was the instrument which the ancient Silpis possessed ? It was their measuring rod called Kol, which was divided into 3 Yonis of 8 Angulas each ; and if Vyaya is another division of their Kol, a yoni of $\frac{1}{3}$ Kol is again divided into $\frac{1}{3}$ parts, and this $\frac{1}{3}$ again into $\frac{1}{3}$ and so on to infinity. In this process of division first they appear to have made a halt at divisions, for in their Vyaya scale it is the $\frac{1}{9}$th divisions that they are using, each Vyaya is equal to $\frac{1}{9}$ h of a Kol. At the same time to know how far they could go they have taken the divisions to infinity, and got the limiting value. It should be re-

membered in their perimeters they were adding one Yoni or $\frac{1}{8}$ of a Kol at a time, though they rejected the odd Yonis. Therefore to conceive of $\frac{1}{8}$ divisions to the infinity was a natural consequence. Should we credit the Ancient Silpis with a knowledge of Geometrical series? But it is generally accepted now, even by Western writers, that the Ancient Hindus knew about the Arithmetical and Geometrical series.

The reason for stating that they halted at the process of division at $\frac{1}{9}$ is that the units of their Vyaya measure, as has already been pointed out, is $\frac{1}{9}$ Kol. The division of $\frac{1}{9}$ is peculiar in one respect, for $\frac{1}{9}$ gives $\cdot 111111 \ldots$ or $\cdot\dot{1}$; $\frac{2}{9}$ gives $\cdot\dot{2}$; $\frac{3}{9}$ gives $.\dot{3}$, and so on till $\frac{9}{9} = 1$, which in fact is only $\cdot 99999999 = .\dot{9}$. These are all never ending figures, but to decide where it should stop, or how far their instruments were capable of dealing with them, they put a limit according to the nature of their instruments. This presumably is their Vyaya measure, in which 10 such divisions were used. The Vyaya measure, as has been shown, consists of 10 one-ninth Kol divisions, with a total of one and one-ninth kol. By taking 10 divisions for this rod, they created further facility, by converting it to a scale of decimals.

It appears that the Vyaya measure did not always contain ten divisions of $\frac{1}{9}$ Kol. For in Manushyalaya Chandrika a third series of Vyaya is mentioned. They were to be found by multiplying the perimeter by 9 and dividing the product by 8. This form of Vyaya is still in use in Northern India; it was once quoted to me by a Banaras Pandit; the use of it was not in connection with the Aya-Vyaya comparison, but for determining a suitable area for houses, by the application of a formula given in "Pinda-Prabha-Kara." The frame work of the

formula shows that there are only 8 Vyayas in this group and each consisted of $\frac{1}{9}$ of a Kol. This incidentally shows that the total measure of the Vyaya measure as $\frac{8}{9}$ kol. This Vyaya formula, when it is applied to the perimeters, the Vyaya fractions are given to 3 places of decimals, while the Vyayas from $\frac{P \times 9}{10}$ give the fractions only to one place of decimal. For instance the Vyayas for the perimeters 2 Kols, 3 Kols, and 5 Kols-16 Angulas respectively are (i) by the application of Formula $\frac{P \times 9}{10}$ 0.8, 0.7, 0.1 and (ii) by the application of the formula $\frac{P \times 9}{8}$, 0.250, 0.375, and 0.375. As the usage of fractions to more places of decimals than one place is envisaged in the latter form of Vyaya, it may be thought that $\frac{P \times 9}{8}$ form of Vyaya is of later origin, as with the advancement of Science greater accuracy is to be expected. But this Vyaya measure does not form the limiting value of Geometrical series, hence it is unsuitable for finer divisions. It is clear that their Aya measure gave them a never ending measure, while their Vyaya measure gave them an instrument accurate to one place of decimal. If it is so, the meaning of both Aya and Vyaya can be ventured, Aya was what they had to spare and Vyaya was what they could easily use; Aya thus became income and Vyaya expenditure.

When they were prepared to give accuracy only to one place of decimal, the ruling given by Manasara for converting an inauspicious Aya into an auspicious Aya is significant. The rule was to add one-thirtieth of Aya to itself. But Ayas became auspicious or inauspicious only in comparison to the respective Vyayas; and all Ayas are recurring decimal fractions. When

$\frac{1}{80}$th of itself is added to a recurring decimal, the first part of it becomes non-recurring. For instance add one-thirtieth of $\dot{1}$ to $\dot{1}$; the result is $.0\dot{0}3\dot{7}$. Add $\frac{\cdot\dot{6}}{30}$ to $\cdot\dot{6}$ the result is $\cdot 6\dot{8}$ From these it may be concluded that the inauspiciousness in Aya was its entire recurring quality, and the remedy suggested by Manasara was to remove its recurring nature to the second or furthers place of decimals.

It may be pointed out however, that the inauspiciousness of the perimeter Aya, or Aya derived for the perimeter, is not remedied by adding to it one-thirtieth of itself. For instance, take any perimeter 7 kols 16 Angulas. Its Aya from $\frac{P \times 8}{12}$ is $.\dot{1}$ and Vyaya from $\frac{P \times 9}{10}$ is .9. But by adding one-thirtieth of $.\dot{1}$ to itself it becomes $.1\dot{1}4\dot{8}$, which is not greater than .9.

The auspiciousness or inauspiciousness is concerned only to the first part of the decimal fraction as it can further be seen from the Vyayas derived from the formula $\frac{P \times 3}{14}$. As there are 14 Vyayas in this group, they are $\frac{1}{14}$, $\frac{2}{14}$ . . . . . $\frac{14}{14}$. Their respective values in decimals are given in Table V.

TABLE V

Vaya fraction for $\frac{P\times 3}{14}$	Decimal Equivalent	Odd or Even
$\frac{1}{14}$	$.0\dot{7}1428\dot{5}$	odd
$\frac{2}{14}$	$.\dot{1}4285\dot{7}$	even
$\frac{3}{14}$	$.2\dot{1}4285\dot{7}$	odd
$\frac{4}{14}$	$.\dot{2}8571\dot{4}$	even
$\frac{5}{14}$	$.3\dot{5}7142\dot{8}$	odd
$\frac{6}{14}$	$.\dot{4}2857\dot{1}$	even
$\frac{7}{14}$	$.4\dot{9} = .5$	odd
$\frac{8}{14}$	$.\dot{5}7142\dot{8}$	even
$\frac{9}{14}$	$.6\dot{4}2857\dot{1}$	odd
$\frac{10}{14}$	$7\dot{1}4285\dot{7}$	even
$\frac{11}{14}$	$\cdot 7\dot{8}5714\dot{2}$	odd
$\frac{12}{14}$	$\cdot 8\dot{5}7142\dot{8}$	even
$\frac{13}{14}$	$\cdot 9\dot{2}8571\dot{4}$	odd
$\frac{14}{14}$	$\cdot\dot{9}$ or 1	even

Some of these are purely recurring dec'ma's, while others have non-recurring decimals at the commencement. But there is a further pecul arity and that is that all the Odd Vyayas have a non-recurring decimal at the commencement; and it is only these Vyayas that one will get, w h n the perimeters belonged to the accepted Yonis. The majority of even Vyayas are purely recurring decimals, while those who begin with non-recurring decimals do not come into consideration at all; for such will not occur in the accepted perimeters.

TABLE VI.

Yonis.	Perimeter in Kols	Aya $\frac{P \times 8}{12}$		Vyaya $\frac{P \times 9}{10}$		Aya Greater or less	Aya in Angula.	Vyaya in Angula.	Aya : Vyaya in Angula.	Vyaya $\frac{P \times 3}{14}$		Aya : Vaya.
		Aya	Aya fraction.	Vyaya	Vyaya fraction.					Vyaya	Equivalent Angulas.	
I	$\frac{1}{3}$	$2\frac{2}{3}$	$.\dot{2}$	3	.3	Less	8	8	1:1	1	8	1:1
II	$\frac{2}{3}$	$5\frac{1}{3}$	$.\dot{4}$	6	.6	Less	16	16	1:1	2	16	1:1
III		8	$.\dot{6}$	9	.9	Less	24	24	1:1	3	24	1:1
IV	1	$10\frac{2}{3}$	$.\dot{8}$	2	.2	Greater	32	$5\frac{1}{3}$	6:1	4	32	1:1
V	$1\frac{2}{3}$	$1\frac{1}{3}$	$.\dot{1}$	5	.5	Less	4	$13\frac{1}{3}$	$\frac{9}{10}:1$	5	40	1:10
VI	2	4	$.\dot{3}$	8	.8	Less	12	$21\frac{1}{3}$	$\frac{3}{16}:1$	6	48	1:4
VII	$2\frac{1}{3}$	$6\frac{2}{3}$	$.\dot{5}$	1	.1	Greater	20	$2\frac{2}{3}$	$7\frac{1}{2}:1$	7	56	$1:2\frac{4}{5}$
VIII	$2\frac{2}{3}$	$9\frac{1}{3}$	$.\dot{7}$	4	.4	Greaaer	28	$10\frac{2}{3}$	$2\frac{5}{8}:1$	8	64	$1:2\frac{2}{7}$
I	3	0	0	7	.7	Less	0	$18\frac{2}{3}$		9	72	
II	$3\frac{1}{3}$	$2\frac{2}{3}$	$.\dot{2}$	0	0	Greater	8	0		10	80	1:10
III	$3\frac{2}{3}$	$5\frac{1}{3}$	$.\dot{4}$	3	.3	Greater	16	8	2:1	11	88	$1:5\frac{1}{2}$
IV	4	8	$.\dot{6}$	6	.6	Greater	24	16	$1\frac{1}{2}:1$	12	96	1:4
V	$4\frac{1}{3}$	$10\frac{2}{3}$	$.\dot{8}$	9	.9	Less	32	24	$1\frac{1}{3}:1$	13	104	$1:3\frac{1}{4}$
VI	$4\frac{2}{3}$	$1\frac{1}{3}$	$.\dot{1}$	2	.2	Less	4	$5\frac{1}{3}$	$\frac{3}{4}:1$	0	0	

This shows that though the Malayaly Silpis have made a mistake in the indiscriminate use of $\frac{P \times 3}{14}$ Vyaya, with $\frac{P \times 8}{12}$ Aya, it so happens through providence or design that their wrong practice did not affect the science materially as the perimeters which could have been affected had been set aside by a previous test. Apparently this form of Vyaya is a well thought out one and should be used only with the perimeters obtained from the Ishta-Dirgha Formula.

Still the reason for Aya to be greater than Vyaya is yet to be found. Probably an investigation into the behaviour of some good and bad perimeters may bear fruit. Take the following instances :—

With perimeters derived from the Ishta-Dirgha Formula,

Aya formula . . . . : $\frac{P \times 8}{12}$

Vyaya . . . . : $\frac{P \times 9}{10}$

Example ( ) P = 3 Kols 16 Angulas whose Aya is greater than Vyayas. Its Aya is $5\frac{1}{3}$ or each Aya being of three-angula bits, total Aya = 16 Angulas, while its Vyaya is three two and two-third Angula bits, which is equal to 8 Angulas. Therefore the Aya remainder is twice the Vyaya remainder.

Example (i). P = 4 kols 8 Angulas, whose Aya is less than its Vyaya its Aya is $7\frac{1}{3}$, which is equal to 22 Angulas. Its Vyaya is = $5\frac{1}{2}$ or $14\frac{2}{3}$ Angulas. Here Aya is not a nice round multiple of the Vyaya.

Example (iii). P = 4 kols, whose Aya is greater than Vyaya. Its Aya is = 8, which is equal to 24 An-

gulas. Its Vyaya is 6, which is = 16 Angulas. Here Aya is one and a half times the Vyaya.

Example (iv). P = 5 kols, 8 Angulas, whose Aya is less than Vyaya. Its Aya is $6\frac{2}{3}$, which is equal to 20 Angulas. Its Vyaya is 8, which is equal to $21\frac{1}{3}$ Angulas. Here Aya is not a multiple of Vyaya.

From these examples and the examples shown in Table VI it will be seen when the Aya is greater than Vyaya, and when Aya and Vyaya remainders are taken in Angulas, Ayas are convenient multiples of Vyaya, and these convenient multiples are 6, $7\frac{1}{2}$, $2\frac{5}{8}$, 2, $1\frac{1}{2}$, $10\frac{1}{2}$, $2\frac{1}{4}$, etc. But it will be seen that some of these belong to Yonis that should be avoided, and when these are rejected the multiples left over are $7\frac{1}{2}$, 2, $10\frac{1}{2}$, 3, $1\frac{1}{2}$, etc.

This might be the reason for their deciding that Aya should be greater than Vyaya; they wanted to get convenient remainders, probably to enable them to set out the work easily and conveniently. Now this conclusion cannot but create some doubt about the nature of the Ayas of the Perimeters like 3, where there are no Aya remainders. Some interpretors of the Silpa Sastras state that the divisor 12 should be taken as Aya in such cases. When 12 is taken as Aya, its equivalent Angulas =36; its corresponding Vyaya $(p \times \frac{9}{10})$ for the Perimeter 3, is 7, which is equal to $18\frac{2}{3}$ Angulas. The resultant proportion between the Aya and Vyaya is $1\frac{3}{4}$: 1, which is not a convenient multiple like 1_2 or 2. The interpretors therefore are not correct; and Aya in such cases should be taken as Zero. This should also apply to Vyayas, if after Vyaya division, no remainder is left, the Vyaya of the measure should be taken as Zero.

When the Vyayas from the formula $\frac{P \times 3}{14}$ are campared to the Ayas of the Formula $\frac{P \times 8}{12}$ the Angulas derived from Aya fractions are always less than the Angulas derived from the Vyaya fractions, so any comparison becomes absurd. But when $\frac{P \times 3}{14}$ Vyayas are compared to $\frac{2(P + \frac{1}{3}P)}{8}$, where the Aya is greater the relation between the Aya and Vyaya remainder in Angulas are indefinite proportions. See Table VII

TABLE VII

Perimeter		Aya $\frac{2(P+\frac{1}{3}P)}{8}$		Vya $\frac{P \times 3}{14}$		Aya Greater or less	Aya in Angula	Vyaya in Angula	Aya: Vyaya
Kol.	Ang.	Aya	Aya Fraction	Vya	Vya Fraction				
3	0	0	0	9	$.5\dot{4}28571\dot{1}$	Less	0	72	
5	16	$7\frac{1}{9}$	$.\dot{8}$	3	$.2\dot{1}4285\dot{7}$	Greater	64	24	$2\frac{2}{3} : 1$
8	8	$6\frac{2}{9}$	$.\dot{7}$	11	$.7\dot{8}5714\dot{2}$	Less	56	88	$1\frac{7}{11} : 1$
11	0	$5\frac{1}{3}$	$.\dot{6}$	5	$.3\dot{5}7142\dot{8}$	Greater	48	40	$1\frac{1}{5} : 1$
13	16	$4\frac{4}{9}$	$.\dot{5}$	13	$.8\dot{2}8571\dot{4}$	Less	40	104	$1\frac{5}{13} : 1$
16	8	$3\frac{5}{9}$	$.\dot{4}$	7	$.4\dot{9}$	Less	32	56	$\frac{4}{7} : 1$
19	0	$2\frac{2}{3}$	$.\dot{3}$	1	$.0\dot{7}1428\dot{5}$	Greater	24	8	$3 : 1$

This conclusively proves the assumption made earlier that the practice of comparing $\frac{P \times 3}{14}$ Vyayas with the $\frac{P \times 8}{12}$ Ayas is wrong, and the presumptions of the Malayaly Silpis is incorrect.

Encouraged by whatever light that has become visible so far in the confused and complicated affair of Aya-Vyaya comparison one may be inclined to go a step further into the darkness of the Vara —Nakshatra and Vara-Thithi tests. But here one is liable to meet with disappointment. The chief reason is the confusion caused by identical names in Silpa Sastras and Astrology. It has already been pointed out what confusion and misunderstanding had been caused by the introduction of caste names to Yoni constants, but here the confusion became most confounded as the Silpis and Astrologers were the same, each studied the art and science of the other, and the scribes had also pretensions to be Astrologers and Silpis alike. The Silpa sastras are most indefinite about these tests, and Silpis are conspicuously vague about their application, and those who confirm to the rule do so only by fear of a bad combination of the stars and planets.

The Varas are represented by the Week-days, which in turn are represented by seven planets including the Sun, the Hindus called the Sun and planets by the common name "Graha." The Nakshatras in Silpa Sastras are the twenty-seven which divide the eclyptic circle into 27 equal parts, but not Nakshatras whose appearance herald the commencement of respective days of the siderial computation of the Tamil Calender. Both the Astrologers and Astronomers, used the terms planets and Nakshatras but the Astrologers gave probably undue prominence or veneration to the conjunction of the planets with the stars, or their appearance on the same

line or spot, which the Astronomers considered as land marks to facilitate their calculations. The S'lpis should not have had any veneration to the stars or fear of their conjunction with the planets. Being practical men their own preoccupation should have been with good or bad measurements. The Varas divided the circle into seven equal parts, while the Nakshatras divided it into 27 equal parts. The Silpis appear to have taken full advantage of these divisions, and utilised them, for their own ends. It has already been shown that their scale of measurement was based on a progressive scale of eights from the bottom, or one-eighths from the top. Their Yoni was one eighth of a Yoni cycle, their Angula was one-eighth of a Yoni, while the Yaya was one-eighth of an Angula and so on to Parma-Anu. Starting from the Angula which is generally the unit of their Kol of 24 Angulas, the successive lower divisions may be set down to represent a geometrical series, thus :—

$$\frac{1}{8} + \frac{1}{8^2} + \frac{1}{8^3} + \frac{1}{8^4} + \ldots\ldots \infty = \frac{1}{8-1} = \frac{1}{7}, \text{ showing}$$

the limiting value of this series when taken to infinity as one-seventh. This quality of the fraction they appear to have taken advantage of. But it will be evident from the application of the Vara Formula that they did not divide their Angulas into sevenths. The Vara formula, a stated before is $\frac{P \times 8}{7}$

The process of multiplying $P \times 8$ has the effect of pulverising the Kol measure into three-Angulas bits ; and it is these three-Angulas bits that are being divided by 7. It may be recalled to mind that it was the same three-Angula bits that were divided by 12, in the process of finding out the Ayas. Here again it was the remainders that were giving the Silpis trouble.

Naturally the remainders obtained by seven will be any number from one to seven and for each of these numbers they gave the name of a Vara for identification, beginning from Sunday; Sunday for one, Monday for two, Tuesday for three, Wednesday for four, Thursday for five, Friday for six and Saturday for seven. They could have identified these remainders by any other recognised group of seven for instance, Saptrshis (the seven stars of the great bears) or the seven seas. They also had separate names for all the twelve remainders of the Aya Formula. These Vara remainders are evidently compared to the Nakshatra remainders, which are obtained by multiplying the perimeter by 8 and dividing by 27.

Here the division by twenty-seven is equal to taking one-third of one-third of one-third, or one-third of one ninth. In Yoni, we have already become acquainted with one-third divisions of their measuring rod Kol, and in Vyaya we have become equally acquainted with the one-ninth divisions. It was also seen that their instrument of accuracy Vya was to the extent of one-ninth. Here it is the same Vyaya instrument that is further divided into one-thirds. In other words, the Kol, or their measuring rod was first divided into three, namely three Yonis then each of the Yoni was divided into three Vyayas, and lastly each of the Vyayas was divided into three Nakshatras.

Decidedly a comparison between hese remainders are introduced presumably for the purpose of convenient disposal. In Vara thithi comparison too the object seems to be the same.

Thithis are found by multiplying the perimeter P by 8 and dividing by thirty. Unfortunately there was no recognised group of thirty; if there were thirty recognised castes, the names of those castes may have been given to these thirty remainders,

But they had a recognised group of fifteen, namely Thithis, and fortunately to their purpose a double set of them too, in a full month of thirty days. It was these names of the Lunar days which the Ancient Silpis gave to the thirty remainders obtained by the process of dividing by thirty.

In the case of the Nakshatras, the effect of division by 27 was dividing Vyayas into thirds again; and it will also be observed that the effect of dividing by 30 in the process of finding Thithi is to divide Vyaya divisions into ten divisions again. This shows the existence of two different practices. They might have existed in different parts of the country, or at different times. However it is evident that long before the first book on Silpa-sastra was written, both the practices were in common use. But it appears that the Thithhi computation had taken a secondary place to Nakshatra computation.

The Table VIII gives the Varas, their order or index numbers, and corresponding Fractions of the Angulas which they stand for.

TABLE VIII

1	2	3	
Names of Days.	Order or Index Number.	Corresponding Angulas.	
		In Fraction.	In Deimals.
Sunday	1	$\frac{3}{7}$	$0\cdot\dot{4}2857\dot{1}$
Monday	2	$\frac{6}{7}$	$0\cdot\dot{8}5714\dot{2}$
Tuesday	3	$\frac{9}{7}$	$1\cdot\dot{2}8571\dot{4}$
Wednesday	4	$\frac{12}{7}$	$1\cdot\dot{7}1428\dot{5}$
Thursday	5	$\frac{15}{7}$	$2\cdot\dot{1}4285\dot{7}$
Friday	6	$\frac{18}{7}$	$2\cdot\dot{5}7142\dot{8}$
Saturday	7	$\frac{21}{7}$	$3\cdot0$

The Tables IX and X give the Nakshatras and Thithis with their index numbers in each group being equal to 3 Angulas; it will be apparent that these tests were intended to deal with very small measurements.

TABLE IX

1	2	3	
Names of Nakshtras.	Order.	Corresponding Angulas.	
		In Fraction.	In Decimals.
Aswasthi	1	$\frac{3}{27} = \frac{1}{9}$	$0\cdot\dot{1}$
Bharani	2	$\frac{2}{9}$	$0\cdot2$
Karthika	3	$\frac{3}{9}$	$0\cdot\dot{3}$
Rohini	4	$\frac{4}{9}$	$0\cdot\dot{4}$
Makayiran	5	$\frac{5}{9}$	$0\cdot\dot{5}$
Athira	6	$\frac{6}{9}$	$0\cdot\dot{6}$
Punartham	7	$\frac{7}{9}$	$0\cdot\dot{7}$
Pooyam	8	$\frac{8}{9}$	$0\cdot\dot{8}$
Ayilyam	9	1	$1\cdot\dot{0}$
Makum	10	$1\frac{1}{9}$	$1\cdot\dot{1}$
Pooram	11	$1\frac{2}{9}$	$1\cdot\dot{2}$
Uthiram	12	$1\frac{3}{9}$	$1\cdot\dot{3}$
Attam	13	$1\frac{4}{9}$	$1\cdot\dot{4}$
Chithira	14	$1\frac{5}{9}$	$1\cdot\dot{5}$
Chothi	15	$1\frac{6}{9}$	$1\cdot\dot{6}$
Vishakham	16	$1\frac{7}{9}$	$1\cdot\dot{7}$
Anizam	17	$1\frac{8}{9}$	$1\cdot\dot{8}$
Ketta	18	$2\cdot0$	$2\cdot0$
Moolam	19	$2\frac{1}{9}$	$2\cdot\dot{1}$
Pooratam	20	$2\frac{2}{9}$	$2\cdot\dot{2}$
Utthiratam	21	$2\frac{3}{9}$	$2\cdot\dot{3}$
Onam	22	$2\frac{4}{9}$	$2\cdot\dot{4}$
Avittam	23	$2\frac{5}{9}$	$2\cdot\dot{5}$
Chathayam	24	$2\frac{6}{9}$	$2\cdot\dot{6}$
Poorooritttathi	25	$2\frac{7}{9}$	$2\cdot\dot{7}$
Uthirittathi	26	$2\frac{8}{9}$	$2\cdot\dot{8}$
Revethai	27	$3\cdot0$	$3\cdot0$

TABLE X

1	2	3	
Name of Thithis	Order.	Corresponding In Fraction.	Angulas. In decimals.
1st Half.			
Prathipada	1	$3/30 = \frac{1}{10}$	0.1
Dwithiya	2	$\frac{2}{10}$	0.2
Thrithiya	3	$\frac{3}{10}$	0.3
Chathurthi	4	$\frac{4}{10}$	0.4
Panchami	5	$\frac{5}{10}$	0.5
Shashthi	6	$\frac{6}{10}$	0.6
Saptami	7	$\frac{7}{10}$	0.7
Astami	8	$\frac{8}{10}$	0.8
Navami	9	$\frac{9}{10}$	0.9
Desami	10	1.0	1.0
Ekadasi	11	$1\frac{1}{10}$	1.1
Dwadasi	12	$1\frac{2}{10}$	1.2
Thrayodasi	13	$1\frac{3}{10}$	1.3
Chathurdasi	14	$1\frac{4}{10}$	1.4
Amavasi	15	$1\frac{5}{10}$	1.5
2nd Half.			
Prathipada	16	$1\frac{6}{10}$	1.6
Dwithiya	17	$1\frac{7}{10}$	1.7
Thrithiya	18	$1\frac{8}{10}$	1.8
Chathurthi	19	$1\frac{9}{10}$	1.9
Panchami	20	2.0	2.0
Shashti	21	$2\frac{1}{10}$	2.1
Saptami	22	$2\frac{2}{10}$	2.2
Ashtami	23	$2\frac{3}{10}$	2.3
Navami	24	$2\frac{4}{10}$	2.4
Dasami	25	$2\frac{5}{10}$	2.5
Ekadasi	26	$2\frac{6}{10}$	2.6
Dwadasi	27	$2\frac{7}{10}$	2.7
Thrayodasi	28	$2\frac{8}{10}$	2.8
Chathurdasi	29	$2\frac{9}{10}$	2.9
Poornamasi	30	3.0	3.0

In Aya-Vyaya comparison it was enjoined that Aya should be greater than Vyaya, but in Vara-Nakshatra and Vara-Thithi tests, it is a suitable Yoga or combination that was required. When certain Nakshatras come with certain Vara a particular Yoga takes place. For instance when Sunday comes with any of the Nakshatras, Uttiram, Uttiratam, Uttirittati, Revati or Onam, it is Sidha Yoga (a combination with the desired result) which is the best. When Wednesday comes with the—Thithis, Panchami and Saptmi it is Amrita Yoga (ever good combination) which is also good; but when Monday comes with Visakham and Chittira, it is bad, the first combination being Mritya Yoga (death giving combination) and the second being Asubha Yoga (bad combination). This sounds like astrology. If one equals all the Varas and Nakshatras of the Sidha Yoga and Asubha Yoga or all the Thithhis and Varas of all the good and bad Yogas, no result which is mathematically satisfactory, in confirmity with the names of the Yogas, can be obtained. It may appear therefore that what the Silp's thought of having might have been a comparison like Aya-Vyaya, where one remainder should be greater than the other, or one a convenient multiple of the other. The comparison of Vara remainders with Thithi remainder too with reference to acceptable Yogas, does not give a mathematically acceptable solution. Hence it may be presumed that Yogas are intruders in the Silpa-Sastras.

Vayas or Age is another problem, which is difficult of solution Ages as it has been shown were derived from dividing the Nakshatra cycles by five, and they were 5 in numbers.

Let the perimeter be 33 Kols 16 Angulas. When it is multiplied by 8 we get 269 Kols 8 Angulas; when that is divided

by 27, the quotient is 9 and the remainder in their deo-decimal system is 26 kols 8 Angulas. The remainder is the Nakshatra while the quotient 9 divided by 5 giv es the remainder 4; which is the Vayas or Age of the perimeter; the stage indicated by 4 is Old Age.

Of Ages as it is stated before, Manhood is the best, though Youth can also be accepted; Vardhkyam and Balyam to be avoided; and Death should never be considered. If this rule is followed, it has virtually the effect of rejecting all the measurements from Zero to 6 Kols 8 Angulas, and again all the measurements from 13 Kols 12 Angulas to 20 Kols 6 Angulas, lim.ting the acceptable ones within the range of 6 Kols 18 Angulas and 13 Kols 12 Angulas. Their difficulties, irrespective of their nature, may have been confined to the fractional parts of the measurement and not on such whole sale rejection of measurements. I am inclined to think that this is a mistake that crept in inadvertantly in the Silpi practice due to the names given to these cycles. Man has ever been frightened of death, and so the Cycle indicated by the name of death became unacceptable, hence it may be the reason for its rejection. These names might have been introduced only to distinguish cycles, to grasp at a glance how far they have advanced in the process of division by 27. To show that it had no other significance the following facts may be mentioned. In Manushyalaya Chandrika another system of finding Vayas is given. It says that the perimeter should be multiplied by 27 and then divided by 20 to find the Vayas; of the remainders thus obtained, the first four should be considered as Balyam, the second four as Kaumara, the thi d four as Yuvana, the fourth four as Vardhakyam and the fifth four as Maranam. When this formula is accepted

some figures accepted by the previous formula will have to be rejected. Each formula might have its own sphere of application; but the real significance cannot be ascertained without further data. However it can be safely suggested that it was a means of locating lengths divided into very small units, probably by placing on a spiral curve, as was in the case of the Yonis. Was this ever used in dividing the arc of a circle into 120 equal parts?

It cannot but be regretted that the Silpi tests for measurements exist only in undefined terms, vague references, unavoidably associated with Astrology and unintentionally mixed up with superstition. Many a scholar tried to break through the Veil and left them with disgust as no rhyme or reason could be attributed. However, they, as it is shown above, are not actually as bad as all that. The sum and substance of my investigation may be summarised as follows:—

(I) The Silpis from time to time made reforms in their measuring rods, to simplify their calculation, and to get suitable measurements for construction and computation.

(II) The first step in the reform was the introduction of the Yoni Measure, which was nothing but a computation on their measuring Rod called Kol. The measuring Rod had already 24 divisions called Angulas. This was divided into three Yonis, each equal to 8 Angulas. The division into one-third had the advantage of getting never ending fractions like 0.3333333 . . . .

(III) They made Yoni a unit for constructional purpose. So every measurement was tested by this unit, and made every acceptable measure to fit in with the Yoni Units, by the introduction of the "Ishta-Dirgha" Formula. Then by making certain restrictions in the application of the formula, they discarded all

the even Yonis as unsuitable, and accepted only the odd Yonis as they were susceptable of giving never ending fractions.

(IV). Then they introduced two measures or scale to test further the accepted measurements obtained by the application of the Ishta-Dirgha Formula. The units on these measuing scales were called Aya and Vyaya respectively. The earliest of the Aya scales had units equal to $\frac{3}{8}$ths of the Measuring Rod Kol, or 9 Angulas in its smaller units, and as such there was no need for the introduction of an entirely new rod, as calculations could be done on the basis of their old scale. At this stage Yoni with the measure of 8 Angulas appears to have been their constructional units. The introduction of these scales appear to have been for the purpose of first getting an approximate measure, and then to see how far it was suitable to be used with the units of their constructional Rod. Hence a comparison between the two became necessary. Now-a-days it is the usual practice to make new scales mechanically and calibrate them according to the requirement. The ancient Silpis instead of making them mechanically devised formulae to fix their units. The Aya and Vyaya formulae originated in this fashion. The total lengths of these Rods appear to have no better significance than its use in fixing the units. Time passed, they felt the need for finer divisions on their constructional units. So they introduced new Vyaya rods. The different kinds of Vyayas that one meets in the Silpa sastras show their struggle in this direction. Their final effort is seen in the Vyaya from the Formula P × 9 divided by 10. This appears to have given birth to a new Vyaya Rod. This rod had ten divisions each equal to 1/9 Kol, which did not fit in with their existing divisions of the Angula on the Kol rod. They appear to have calibrated the one-ninth divisions by an ordinary

graphical construction having reference to their Kol measure. The total length of this rod was and $1\frac{1}{9}$ Kol with ten equal divisions, which shows the ancient Silpis at any rate took advantage of their discovery of " Sunya " or Zero and the place value notation. They must have found the practical value of ten apart from its devotional association, and defficiency in number of factors for easy reckoning. When they fixed this rod as their constructional measure, they felt the need for a change in the Aya Rod. Probably after a great deal of struggle, they fixed on the Aya derived from $P \times 8$ divided by 12. The unit measure on this Rod was $\frac{1}{8}$ Kol or 3 Angulas of their old Measuring Rod Kol, while it had the advantage of a larger number of factors for easy calculation. Lancelot Hogben says :—"For the purpose of calculation 10 is a bad number, however holy its devotional association and however venerable its Biological antecidents. It has only three exact divisions: 1, 2, 5. The number 12 has 1, 2, 3, 4, 6, as its divisors, and the number 60 has 1, 2, 3, 4, 5, ,6, 12, 15, 20, 30. A large number of factors is a great advantage in rapid calculation. So it would be an improvement on our present standard to make a Hegelian compromise of the English and French system by adding two more to the Hindu numeral script, and making a positional notation based on the twelve-figured abacus with weights and measures adjusted accordingly." This suggestion of Lancelot Hogben appears to have been carried out by the Silpis of India in long forgotten days at any rate in respect of Measurement. Their Aya system is none other than that. Here they added two more numbers to their ancient number script, and to avoid confusion they gave each one a different name quite distinct from that of their numbers. Similarly they gave different names to the ten units of their

Vyaya Rod. Unfortunately the nature of these names became their undoing. The names of these Ayas and Vyayas are given in the Manasara; and according to P. K. Acharaya's translation they read thus for Ayas in numerical order :—" The military prosperity, general progress, support, general peace, increase of vigilance, intelligence, beauty, good luck, prosperity, happiness, great increment, and plentifulness." And the Vyayas in numerical order are :—" Fruition, salvation, auspiciousness, increment of prosperity, fortune, fulfilment of wealth, enjoyment, distruction of quarrel and friendship." From these names how is it possible to recognise fractions like $\frac{1}{12}$, $\frac{2}{12}$, $\frac{3}{12}$ . . . . . ; and $\frac{1}{10}$, $\frac{2}{10}$, $\frac{3}{10}$ . . . . . ? No wonder that the Hindus forgot all these in their bad days. Whether or not we appreciate the need for the Aya-Vyaya comparison the Silpis gave the greatest importance to it, as it can be seen even when they did not fully comply with other or later tests, they adhered to this very firmly.

(V). The measurement that came successful through these tests, the Silpis put to further tests. The more ancient of them appears to be the Vara-Thithhi Test. The unit of Vara as will be recognisable from the formula P $\times$ 8 divided by 7 is $\frac{1}{8}$ Kol or 3 Angulas, the same unit as the latest Aya. The Nakshatras and Thithhis also have the same units of measure, and it is these units that are compared with the Vara units. Therefore the scale that is compared and the scale to which they are compared are all in the same units, which augured well for the purpose of investigation. But certain details, which disappeared from the Silpa-sastras, and certain factors which crept in from astrology, make any conclusion difficult. The relation between the Varas and the Nakshatras forms a spiral curve when the Varas put as 7 ordinates or rays covering 360 degrees, and the Nakshatras

are plotted on them. But it will be seen that the co-ordinates of any of the acceptable Yoga fail to give a satisfactory mathematical solution. Further in determining Yogas, Nakshatra fractions are taken approximate, for one-third of a Nakshatra is ommitted, and two-thirds of Nakshatra are taken as one. Hence Yogas may be discarded as factors of not much mathematical consequence. It is just the same in the case of Vara-Thithhi comparison. Therefore Vara, Nakshatra and Thithhi should be investigated for their own respective merits.

All the three have their constructional merits. Vara being a scale of $\frac{1}{7}$th divisions, it lends itself to further divisions $\frac{1}{8}$ ths and $\frac{1}{8}$ ths of one-eighths to infinity. The Hindu scale being a series of one-eight divisions from the Yoni cycle to the infintesimal Paramanava the utility of one-seventh division is self evident. But here the Silpis envisage only divisions from $\frac{1}{8}$ of their Aya division scale—Similarly the Nakshatra being equal to $\frac{1}{27}$ or $\frac{1}{9}$ of $\frac{1}{3}$, and $\frac{1}{3}$ having the facility of being divided into 5th and $\frac{1}{9}$ of one-fourths to infinity, it has also its merits for constructional purpose. It should be remembered that $\frac{1}{9}$ Kol was the unit in their later Vyaya scale. Hence it is obvious that the Nakshatra scale was introduced with units to sub-divide the Vyaya scale. Similarly one Thithhi being equal to $\frac{1}{30}$, and one-thirty being equal to $\frac{1}{3}$ of $\frac{1}{10}$th, and $\frac{1}{10}$ being capable of being divided into $\frac{1}{9}$ and $\frac{1}{9}$th to infinity, it has also a great advantage for constructional purpose. Here also it should be remembered that the Vyaya scale of $\frac{1}{9}$th unit, with ten divisions on the scale, which is being further divided into tenths: Hence both Nakshatra and Thithi are sub-divisions of their Vyaya units. Vayas appear to have no special significance except for the purpose of seeing whether a measure

or cycle of measures have attained the maturity of being divided into $\frac{1}{27}$ths of a Kol.

Hence it will be abundantly clear that Vara, Nakshatra and Thithhi are sub-divisions of their measuring rods and they have nothing to do with the date on which a person was born, whethers he is the owner of a house, or the Silpi who designs and constructs the house. The Silpis or the "Pandits" who think otherwise are doing deservice to their cultured ancestors, who introduced such measures for highly utiliterian purpose, with full knowledge of what they were doing. The Hindus heap discredit on their ancestors by attributing all knowledge and valuable discoveries to Gods; even astronomical truths, which had taken centuries of observations, analysis and study, are not attributed to intelligence, ability and perseverance of their ancestors, but to their "Divyam-Chakshas" or all seeing spiritual eye.

Now it may be legitimately asked if the Silpis used scales or measuring rods such as these, why no trace of them could be found? It is obvious that there was no need for making separate scales for Yoni, Ayas, big Vyaya, and Vara, for their units in Angulas were already on their measuring rod Kol. Small Vyaya stand on a different footing. Its unit being $\frac{1}{9}$ of a Kol or $2\frac{2}{3}$ Angula needed a rod with 10 divisions. The Nakshatra and Thithhi divisions being subdivisions of the Vyaya rod, the discovery of the Vyaya will substantiate their existence as well.

It cannot but be regretted that no full measuring rod was unearthed even in the Indus Valley. But at Harappa a fragmentary one was found. This is a bronze rod 1.5 inches long, broken at both ends, "but with complete four divisions." These

divisions are not absolutely equal. Mr. Madho Sarup Vat by taking each division separately arrived at an average for each as 0.3676 Inch, which when converted into Silpi units will be 0.49013 Angula.

But if all the four divisions taken together the total measure in the Silpi units is $1.5 \times 4 \div 3 = 2$ Angulas. If we realise that the Indus Valley Silpis had not possessed such fine calibrating machinery as we possess to-day, it can easily be seen that this bit of rod is divided into Half Angula units. However, this bit of measuring rod should enable us to come to the conclusion that the measuring rod used by the Indus Valley Silpis was not different from those used by the Hindu Silpis elsewhere.

Table XI shows some of the weights found at Mohenjo-Daro and Harappa side by side with the units of the Hindu measuring rods.

TABLE XI

A				B	
WEIGHTS				LINER MEASURES	
(a) Index Numbers	(b) Mean weight observed	(c) Ratio	(d) Ratio in multiple of 8	(a) Angulas	(b) Name
N	1375	1600	200×8		
M	546.7	640	80×8		
L	272.9	320	40×8		
K	174.5	200	25×8		
J	135.95	160	20×8		
H	54.23	64	8×8	8×8	1 Yoni Cycle
G	27.38	32	4×8		
				3×8	1 Kol
F	13.81	16	2×8	2×8	2 Yonis
E	6.82	8	1×8	1×8	1 Yoni
D	3.41	4	$\frac{1}{2} \times 8$	$\frac{1}{2} \times 8$	$\frac{1}{2}$ Yoni
C	2.28	$\frac{1}{3} \times 8$	$\frac{1}{3} \times 8$	$\frac{1}{3} \times 8$	1 Vyaya
B	1.76	2	$\frac{1}{4} \times 8$	$\frac{1}{4} \times 8$	
A	0.87	1	$\frac{1}{8} \times 8$	$\frac{1}{8} \times 8$	1 Angula
				$\frac{1}{8} \times \frac{1}{8} \times 8$	1 Yava
				$\frac{1}{8} \times \frac{1}{8} \times \frac{1}{8} \times 8$	1 Yuka

Colums A (a), A (b), and A (c). show the Index letters of the weights, mean weights observed, and their ratio respectively as given by Sir John Marshal in his Mohenjo-Daro and the Indus Valley Civilization. (Vol. II. page 591). Column A (d) gives the ratio of the weights in multiples or fractions of eights. Column B (b) shows the lenial measure used by the Hindu Silpis, while column B (a) gives these measures in

multiples or fractions of eights. The similarity between the columns A (d) and B (a) needs no comment. Is it by chance? or is it that the people who made these weights and the measures were the same? Special attention may be drawn to the weight "C." Its ratio is $\frac{8}{3}$ or $2\frac{2}{3}$ times that of the lowest weight "A". What use one could have with a weight of this description? In lenial measures $\frac{8}{3}$ is an enchanted number as it is equal to $2\frac{2}{3}$ or 2.66666, a measure like π, which could be taken advantage of, to the extent that the divisions of one's constructional instrument would permit. The ancient Egyptians called two-thirds by a special name. But what is the use of two and two-third units in a Table of weights? The answer to this question may take the Vyaya measure to Mohenjo-daro and Harappa. $2\frac{2}{3}$ Angula is a Vyaya unit. It appears that the Indus Valley people made their weights to be in parity with their measurements. However the use of this Vyaya rod with $2\frac{2}{3}$ Angulas or $\frac{1}{9}$th Kol division appears to be in evidence both at Mohenjo-daro and Harappa of fourth Millenium B.C.

At Harappa:	A room, in trench II Area J, measures.				
	Length L	=	26 ft. 6 ins.	=	$17\frac{6}{9}$ Kols.
	Breadth B	=	9 ft. 10 ins	=	$6\frac{5}{9}$ Kols.
At Mohenjo-daro:	The Swimming Pool.				
	L	=	39 ft. 0 ins.	=	26 Kols.
	B	=	23 ft. 0 ins.	=	$15\frac{3}{9}$ Kols.
b)	Room 54 in L Area.				
	L	=	13 ft. 2 ins.	=	$8\frac{7}{9}$ Kols.
	B	=	6 ft. 0 ins.	=	4 Kols.
(c)	Room 6 D. K. Area.				
	L	=	26 ft. 6 ins.	=	$14\frac{3}{9}$ Kols.
	B	=	15 ft. 0 ins.	=	10 Kols.

The use of this Vyaya Rod appears to have been continued through the ages. It is found at Kausambi of the fourth century B.C.

A Room L = 12 ft. 6 ins. = $7\frac{3}{9}$ Kols.
B = 7 ft. 0 ins. = $4\frac{6}{9}$ Kols.

It was also in use at Bhita at the beginning of the Christian Era.

(a) Room L = 188 ins. = $10\frac{4}{9}$ Kols.
B = 114 ins. = $6\frac{3}{9}$ Kols.
(b) Room L = 217 ins. = $12\frac{1}{18}$ Ko's.
B = 88 ins. = $10\frac{4}{9}$ Kols.
(c) Pillar: 35 ins. × 37 ins. = $1\frac{17}{18} \times 2\frac{1}{18}$ Kols.
(d) Well Diameter: 40 ins. = $2\frac{2}{9}$ Kols.

If the Silpis at all these sites were not using the Vyaya rod calibrated to $\frac{1}{9}$ of a kol, some other explanation for the existence of these measurements should be found. $\frac{1}{9}$ is not a measure that could be set out without a calibrated rod. Both at Kausambi and Bhita I took the readings with a steel tape, hence there is no doubt about the accuracy of the measurement in inches or their equivalent measures ending in $\frac{1}{9}$ ths of the Kol . . . . . These measurements were not taken to prove the existence of the Vyaya measure, but they were taken only as a matter of curiosity in a trip intended for collecting old coins.

In this chapter, on several occasions, Ayas and Vyayas were shown in Kols and Angulas, which is not actually correct. Ayas and Vyayas should be shown in fractions. But their representation in Kols and Angulas is a Silpi practice. The Silpis had a deo-decimal system based on the main divisions of their Kol into $\frac{1}{3}$ and $\frac{2}{3}$. In English deo-decimals it is the fractions

of a foot $\frac{1}{2}$ and $\frac{1}{4}$ are used. The Silpi system is seen from the following examples :—

Find the Aya of the Perimeter 3 Kols 16 Angulas.

Multiply $P \times 8$ and divide the product by 12 ;

	Kols.		Angulas	
	3	—	16	
			8	
12)	29	—	8	(2
	24			
	5	—	8	

The Aya is written and read as 5 Kols 8 Angulas while actually it is $5\frac{1}{3} \div 12 = \frac{4}{3}$ Kol.

CHAPTER VIII

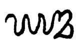
Hindu Fractions and Limiting Values

THE FRACTION LORE OF THE EARLY HINDUS APPEAR TO HAVE been very exhaustive. The first range of fractions, which they envisaged was down to $\frac{1}{320}$ of a unit. These fractions are tabulated in Table XII; Column (2) shows the main fractions. Column (3) shows how they are written. Column (4) shows how they are pronounced. Column (5) shows their make-up and Column (6) shows their equivalent value in decimals.

TABLE XII

1	2	3	4	5	6
Sr. No.	Fractions.	How they are written	How they are called	Their make-up	Decimal equivalent
1	1		Onnu	Forerunner of English one ?	1.0
2	$\frac{3}{4}$		Mu-kal	3 Kal or $3 \times \frac{1}{4}$	0.75
3	$\frac{1}{2}$		Ara	Forerunner of Sanskrit Ardha ?	0.50
4	$\frac{1}{4}$		Kal	K AL = 1 AL Ka stands for one	0.25

TABLE XII: continued—

1	2	3	4	5	6
Sr. No.	Fractions.	How they are written	How they are called	Their make-up	
5	$\frac{1}{5}$		Nan-ma	4 Ma $= 4 \times \frac{1}{20}$	0.20
6	$\frac{3}{16}$		Munt-ani	15 Ani $= 15 \times \frac{1}{80}$	0.1875
7	$\frac{3}{20}$		Mum-ma	3 ma $= 3 \times \frac{1}{20}$	0.15
8	$\frac{1}{8}$		Ara-kal	$\frac{1}{2}$ kal $= \frac{1}{2} \times \frac{1}{4}$	0.125
9	$\frac{1}{10}$		Iru-ma	2 ma $= 2 \times \frac{1}{20}$	0.10
10	$\frac{1}{16}$		Mak-ani	5 Kani $= 5 \times \frac{1}{80}$	0.06375
11	$\frac{1}{20}$		Oru-ma	1 ma $= 1 \times \frac{1}{20}$	0.05
12	$\frac{8}{30}$		Muk-ani	3 Kani	0.0375
13	$\frac{1}{40}$		Ara-ma	$\frac{1}{2}$ ma $= \frac{1}{2} \times \frac{1}{20}$	0.025
14	$\frac{1}{80}$		K -ani	Ka-Ani or 1 Ani (Ka $= 1$) $= 1 \times \frac{1}{80}$	0.0125
15	$\frac{1}{160}$		Ara-kani	$\frac{1}{2}$ kani $= \frac{1}{2} \times \frac{1}{80}$	0.00625
16	$\frac{1}{320}$		Munthiri	Mum-thari	0.003152

It will be seen that the smallest fraction in this group is $\frac{1}{320}$ which was called Munthiri. Double of this they called Arakani. Double of Arakani they called Kani. Double of Kani as Arama and so on. It is no doubt the symbols representing these fractions are a sort of pictograph, and they are still used in Travancore and probably elsewhere as well. These characters may belong to a script called "Nanam, Munam," which was prevalent in Travancore some two centuries ago. Even to-day certain title deeds, of property and men (slaves), written in " Nanam Munam " are found in old family archives. The persons who could decipher these documents are rare. The Script is named after two letters of that alphabet, " Nanam, " equivalent to " Na " and " Munam " equivalent to " Ma," which when conjointed form the expression " Nam-," that means salutation, a phrase to be uttered and written by every child at the initiation to study. Nanam-Munam Script was superceded in Travancore by Tamil Script, which in turn was superceded by the present Malayalam Script. Even then these pictograph characters, symbolising the fractions are still used with Malayalam characters. The likeness between Nanam-Munam characters and these pictograph fractions is most remarkable. For instance Nanam or Na of this script is written as, the same sysmbol for " Oruma " or $\frac{1}{20}$. " Oruma " means one " Ma." It appears therefore since the time of the fractional symbol to the time of Nanam-Munam script " Ma " became " Na." This transformation may not be in accordance with the accepted rules of Malayam grammar, but according to the Hindi usage " M " and " N " are interchangeable, as in the words ' Kumar ' and ' Kunwar.' The symbol for Kal is  while the letter " Ka " in the Nanam-

Munam is written as of showing a common origin. It may be noted that symbol Kal was used by the ancient Egyptians or Greek in their Zodiac sign of Cancer, which is given as . Some of the fractional signs can be traced back to Mohenjo-daro Seals, for instance sign for half as , the sign for Iruma as , part sign for Nanma , etc. Are these mere chances? Or do they show a family likeness or common parentage?

The names of all these fractions appear to be Dravidian, no Sanskrit touch or flavour about them. The formation or the structure of the fractions is also different from Sanskrit ways. One-tenth in Sanskrit is Dasa-amsa, one part of ten divisions; while here it is "Iruma," or "Iru-ma" or two "Mas." Sir John Marshall states that the Indus Valley or Mohenjo-daro language was possibly Dravidian, but he and others are of opinion that the Indus Valley characters, are written from right to left. But these fraction symbols, like all scripts of the Dravidian origin, are written from left to right. Against such high expert opinions it is hazardous to suggest a common origin to these symbols with the pictograph writing of the Indus Valley Civilization. However it might be, there is a close resemblance between these fractions and, the weights found in Mohenjo-daro and Harappa. This may be obvious from Table XIII, where columns, A (a) gives the index "letters" of weights found in Mohenjo-daro and Harappa, and Column A (b) shows their ratios as given by Sir John Marshall. Column B (a) gives the Hindu fractions and Column B (b) the names of the fractions. In comparing Columns A (b) and B (a) it will be seen that the figures of one are the reciprocals of the other.

TABLE XIII

A		B	
(a) Index Letters	(b) Ratio of Indus Valley Weights	(a) Hindu Fractions	(b) Names of the Hindu Fractions
A	1	1	Onnu
B	2	$\frac{1}{2}$	Ara
C	$2\frac{2}{3} = \frac{8}{3}$	$2 \times \frac{3}{16}$	2. Muntani
D	4	$\frac{1}{4}$	Kal
E	8	$\frac{1}{8}$	Ara-kal
F	16	$\frac{1}{16}$	Mahani
G	32	$\frac{1}{32}$	$\frac{1}{2}$Mahani
H	64	$\frac{1}{64}$	$\frac{1}{4}$Mahani
J	160	$\frac{1}{160}$	Arakani
K	200	...	...
L	320	$\frac{1}{320}$	Munthiri
M	640	$2 \times \frac{1}{320}$	$\frac{1}{2}$Munthiri
N	1600	$\frac{1}{1600}$	$\frac{1}{5}$Munthiri $=$ Nanma $\times$ Munthiri

The family likeness between these fractions and the weights are most obvious. How can one account for this strange coincidence? If the Indus people had completely died out with the destruction of Mohenjo-daro, and the incoming Aryans started a new civilisation from the very foundation with their cattle pens and bamboo huts, or the Aryans came as conquerors with a post-vedic civilization from beyond the confines of North-West India, the family likeness between these weights and fractions could not be explained; neither the presence of the Hindu proportions nor the Hindu measuring rods in the Indus Valley. If the inference from these is as it should be, certain chapters of Indian History may need revision.

If one is to judge from the names, the main fractions are :—

Kal $= \frac{1}{4}$

Ma $= \frac{1}{20} = \frac{1}{4 \times 5}$

Ani $= \frac{1}{80} = \frac{1}{4} \times \frac{1}{20} = \frac{1}{4}$ Ma.

and Munthiri $= \frac{1}{320} = \frac{1}{20} \times \frac{1}{16} =$ Ma $\times$ Mah-ani.

Here "Ka," and "Ma", indicate these fractions are based on alphabets. "Ka" even now is considered as one and "Ma" as five. In Sanskrit too the letter numerals plays an important part. It will be recognised that the basic fractions probably except Munthiri are $\frac{1}{4}$ and $\frac{1}{5}$ and the whole series is built upon these.

Generally speaking fractions were originally formed from man's desire to express in halfs. For instance the English Inch is devided into $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$, $\frac{1}{32}$, and it could be further con-

tinued to $\frac{1}{64}$, $\frac{1}{128}$, $\frac{1}{256}$, $\frac{1}{512}$.........each successive ones half of the previous one. But in the Hindu fractions the element of $\frac{1}{5}$, and $\frac{1}{2}$ plays a prominent part. This may take us back to the primitive days. The primitive man counted on his fingers, when he exhausted his fingers he continued the counting on his toes. In Indian languages there is no such fine distinction as toes and fingers, to them all are fingers. The primitive Hindu when he thought of making fractions, he l oked at himself and he saw himself as one or "onnu" or "Oru". He saw he was divided or doubled at his waist into two; he called each half one as "ara" the same name for waist. From waist downwards he saw that his body was distinctly divided into two by his legs. His name for leg was "Kal"; so he called $\frac{1}{4}$ also Kal. Then he looked at his "Kal" or legs for further divisions he saw the fingers" on his "kal" or leg and as there were five toes on each he divided the Kal or $\frac{1}{4}$ into $\frac{1}{5}$ th each. Thus 1 appears to have become divided into $\frac{1}{20}$ to which the Hindu fraction maker gave the name "Ma," hence :—

$\frac{1}{20}$ = 1 Ma = Oru-Ma.

$\frac{2}{20} = \frac{1}{10}$ = 2 Ma = Iru-Ma.

$\frac{3}{20}$ = 3 Ma Mum-Ma.

$\frac{4}{20} = \frac{1}{5}$ = 4 Ma = Nan-Ma.

For $\frac{5}{20} = \frac{1}{4}$, he had already the name "Kal" and

for $\frac{3}{4}$ he gave the name 3 Kal = Mu-kal.

When he became more mathematically minded he felt the need for finer divisions and he divided his " Ma " into, $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$ and $\frac{1}{16}$. He named them as follows :—

$$\frac{1}{5 \times 16} = \frac{1}{80} = 1 \text{ ani} = \text{Kani (K being 1.)}$$

$$\frac{2}{5 \times 16} = \frac{1}{40} = \tfrac{1}{2} \text{ Ma} = \text{Arama (Ara being } \tfrac{1}{2}.)$$

$$\frac{3}{5 \times 16} = \frac{3}{80} = 3 \text{ Kani} = \text{Mukani.}$$

$$\frac{4}{5 \times 16} = \frac{1}{20} = 1 \text{ Ma} = \text{Oruma.}$$

$$\frac{5}{5 \times 16} = \frac{1}{16} = 5 \text{ Kani} = \text{Ma-kani.}$$

The sixth and the seventh appears to have had no special names.

$$\frac{8}{5 \times 16} = \frac{1}{10} = 2 \text{ Ma} = \text{Iru-Ma.}$$

The ninth part had no special name.

$$\frac{10}{5 \times 16} = \frac{1}{8} = \frac{1}{2} \text{ of } \frac{1}{4} = \text{Ara-Kal.}$$

For the 11th part had no special name.

$$\frac{12}{5 \times 16} = \frac{3}{20} = 3 \text{ Ma} = \text{Mum-ma.}$$

No special name for the 13th and 14th.

$$\frac{15}{5 \times 16} = \frac{3}{16} = \frac{3 \times 5 \times 1}{80} = \text{Mun-ta ani.}$$

Note :—Here " Ta " stands for 5. In Sanskrit " Ta " is 1, hence this fraction was framed in pre-sanskrit days.

$$\frac{16}{5 \times 16} = \frac{1}{5} = \text{Nal or nan-ma (4-Ma).}$$

After having connec ed the new divisions of one sixteenth with the old one-twelfth divisions, and after having obtained one Ani or $\frac{2}{80}$ as their smaller fraction, they divided the "kani" again into $\frac{1}{2}$ and $\frac{1}{4}$, thus :—

$$\tfrac{1}{2}\text{kani } \frac{1}{80\times 2} = \frac{1}{160} = \text{Ara-Ma.}$$

$$\tfrac{1}{4}\text{Kani} = \frac{1}{4}\times\frac{1}{80} = \text{Munthiri.}$$

MUMTHIRI has derived from 'Mum' and 'thari'. 'Thari' in alphabetical numerals is equivalent to 320 (for tha = 3 ra = 2 and i = 0).

'MUM' may indicate that it is a fraction of which I am not quite sure..

Munthiri with the value $\frac{1}{320}$ was not the limit of the Hindu fractions; they built up fractions of still lower value down to $\frac{1}{320\times 320}$ = 0.0000009140625. In doing this, they did not actually give different names, but put the word "kil" as a prefix to all fractions from Mukal = $\frac{3}{4}$ to Munthiri = $\frac{1}{320}$, like Kil Mukal, Kil Ara, Kil Kal, Kil Arakal and so on to Kil Muthiri thus making Kil Munthiri equal to $\frac{1}{320}$ of $\frac{1}{320}$

(NOTE : 'l' to be pronounced as 'd' in 'Ridge')

The most important fractions of this group are shown in *Table XIV*

TABLE XIV

1	2	3	4
Sr. No.	Name.	Make up.	Equivalent fractions.
16.	Munthiri		$\frac{1}{320}$
17.	Kil-Kal	$\frac{1}{4}$ Munthiri	$\frac{1}{4} \times \frac{1}{320}$
18	Kil Oruma	$\frac{1}{5}$ Kil-Kal	$\frac{1}{20} \times \frac{1}{320}$
19.	Kil Arama	$\frac{1}{2}$ Kil-Oruma	$\frac{1}{40} \times \frac{1}{320}$
20.	Kil-Kani	$\frac{1}{2}$ Kil-Arama	$\frac{1}{80} \times \frac{1}{320}$
21.	Kil-Arakani	$\frac{1}{2}$ Kil-Kani	$\frac{1}{160} \times \frac{1}{320}$
22.	Kil-Munthiri	$\frac{1}{2}$ Kil-Arakani	$\frac{1}{320} \times \frac{1}{320}$

Thus it will be seen that there are two groups of fractions with identical names, but the lower group has Kil before them. Kil in Tamil as well as in Malayalam means below or lower; hence these two groups become upper and lower fractions.

The terms upper and lower must have originated from relative positions in their calculating Board, on which they put different groups of cowries indicating the "Place Value."

What use they made of these fractions may be seen from the following example :—

Question : Divide one by three or evaluate the recurring decimal $0.\dot{3}$ or the never ending fraction 0.333333.

First Step: As 1 cannot be divided by 3, convert 1 into fractions of lower denomination. As 1 contains 4 Kals, 4 Kals can be divided by 3, which process gives 1 Kal for quotient and 1 Kal for remainder.

2nd. Step: Convert the remaining 1 Kal into lower denomination say into Oruma. As one Kal contains 5 Oruma, it can be divided by 3, which process gives for quotient 1 Oruma and for the remainder 2 Orumas.

3rd. Step: Convert the remaining 2 Orumas into Aramas, by multiplying by 2; that gives 4 Aramas, which when divided by 3, gives 1 Arama for the quotient and one Arama for the remainder.

4th. Step: Convert the remaining 1 Arama into Arakanis, by multiplying it by 4; then divide by 3; the quotient is 1 Arakani and the remainder is 1 Arakani, which when converted into Munthiri leaves the remainder 2 Munthiris.

We have so far come to the end of the Table XII. Let us collect the results of the division so far done, we have for the quotients :—

1 Kal + 1 Oruma + 1 Arama + 1 Arakani, and the remainder 2 Munthiris.

i.e. $= \frac{1}{4} + \frac{1}{20} + \frac{1}{40} + \frac{1}{160}$ and remainder $\frac{1}{160}$

$= 0.25 + 0.05 + 0.025 + 0.00625$ and remainder 0.00625.

$= 0.33125$ and remainder 0.00625.

This shows as a result of the division so far done we have evaluated 0.3 correct to two places of decimals. But the division can be carried still further by the use of Table XIV.

5th. Step: Convert the remainder 2 Munthiris into Kil-Kals, which gives 8 Kil-Kals, which when divided by 3, gives 2 Kil-Kals for quotient and 2 Kil-Kals for the remainder.

6th Step: Convert 2 Kil-Kals into Kil-Oruma by multiplying it by 5, which gives 10 Kil-Orumas, which when divided by 3, gives 3 Kil-Orumas for the quotient and 1 Kil-Oruma for the remainder.

7th Step: Convert the remainder Kil-Oruma into Kil-Kani by multiplying it by 4, and when it is divided by 3, the quotient is 1 Kil-Kani and the remainder is 1 Kil-Kani.

8th Step: Multiplying the remainder 1 Kil-Kani by 4, we get 4 Kil-Munthiri, which when divided by 3, the quotient is 1 Kil-Munthiri and the remainder is 1 Kil-Munthiri.

Still we are left without a final solution. But to bring this recalcitrant fraction and other similar fractions they introduced certain equivalents, as shown in *Table XV*.

TABLE XV

1	= 320 Munthiri	
1 Munthiri	= 320 Kil-Munthiri	$= \frac{1}{320}$ Munthiri
1 Kil-Munthiri	= 21 Immi	$= \frac{1}{320} \times \frac{1}{320} = A$
1 Immi	= 7 Anu	$= \frac{1}{21} \times \frac{1}{320} \times \frac{1}{320} = \frac{1}{21} \times A$

1 Anu	= 11	Mummi	$= \frac{1}{7} \times \frac{1}{21} \times \frac{1}{320} \times \frac{1}{320} = \frac{1}{7} \times \frac{1}{21} \times A$
1 Mummi	= 9	Gunam	$= \frac{1}{11} \times \frac{1}{7} \times \frac{1}{21} \times A$
1 Gunam	= 13	Pantham	$= \frac{1}{9} \times \frac{1}{11} \times \frac{1}{7} \times \frac{1}{21} \times A$
1 Pantham	= 17	Chinni	$= \frac{1}{13} \times \frac{1}{9} \times \frac{1}{11} \times \frac{1}{7} \times \frac{1}{21} \times A$
1 Chinni	= 19	Muthu	$= \frac{1}{17} \times \frac{1}{13} \times \frac{1}{9} \times \frac{1}{11} \times \frac{1}{7} \times \frac{1}{21} \times A = B$
1 Muthu	= 23	Vargam	$= \frac{1}{19} \times B.$
1 Vargam	= 25	Thaithanu	$= \frac{1}{23} \times \frac{1}{19} \times B$
1 Thaithanu	= 27	Thai	$= \frac{1}{25} \times \frac{1}{23} \times \frac{1}{19} \times B$
1 Thai	= 29	Tharkam	$= \frac{1}{27} \times \frac{1}{25} \times \frac{1}{23} \times \frac{1}{19} \times B$
1 Tharkam	= 31	Chinnam	$= \frac{1}{29} \times \frac{1}{27} \times \frac{1}{25} \times \frac{1}{23} \times \frac{1}{19} \times B$
1 Chinnam	= 33	Varnam	$= \frac{1}{31} \times \frac{1}{29} \times \frac{1}{27} \times \frac{1}{25} \times \frac{1}{23} \times \frac{1}{19} \times B$
1 Varnam	= 35	Kunkuman	$= \frac{1}{33} \times \frac{1}{31} \times \frac{1}{29} \times \frac{1}{27} \times \frac{1}{25} \times \frac{1}{23} \times \frac{1}{19} \times B$
1 Kukuman	= 37	Kumalayam	$= \frac{1}{35} \times \frac{1}{33} \times \frac{1}{31} \times \frac{1}{29} \times \frac{1}{27} \times \frac{1}{25} \times \frac{1}{23} \times \frac{1}{19} \times B$
1 Kumalayam	= 39	Pasi	$= \frac{1}{37} \times \frac{1}{35} \times \frac{1}{33} \times \frac{1}{31} \times \frac{1}{29} \times \frac{1}{27} \times \frac{1}{25} \times \frac{1}{23} \times \frac{1}{19} \times B$

1 Pasi	= 41 Mandalam	$= \frac{1}{39} \times \frac{1}{37} \times \frac{1}{35} \times \frac{1}{33} \times \frac{1}{31} \times \frac{1}{29} \times \frac{1}{27} \times \frac{1}{25} \times \frac{1}{23} \times \frac{1}{19} \times B = C$
1 Mandalam	= 43 Ninavu	$= \frac{1}{41} \times C$
1 Ninavu	= 45 Rupam	$= \frac{1}{43} \times \frac{1}{41} \times C$
1 Rupam	= 47 Thuti	$= \frac{1}{45} \times \frac{1}{43} \times \frac{1}{41} \times C$
1 Thuti	=	$= \frac{1}{47} \times \frac{1}{45} \times \frac{1}{43} \times \frac{1}{41} \times C$

Take the first equivalent 1 Kil Munthiri = 21 Immi. This enables us to convert the remaining Kil-Munthiri into 21 Immis. Now apply the 9th Step in the division : divide 21 by 3, which gives 7 for the quotient, without leaving any remainder.

Thus the never ending process of division was brought to a close by the device called Immi. Let us now see what accuracy has been attained in the evaluation of $0.\dot{3}$. The quotients are :—

1 Kal	=	0.25
1 Oruma	=	0.05
1 Arama	=	0.025
1 Arakani	=	0.00625
2 Kil-Kal	=	0.0015625
3 Kil-Oruma	=	0.00046875
1 Kil-Kani	=	0.0000365665
1 Kil Munthiri	=	0.0000091406625
7 Immi	=	0.000003046875
TOTAL	=	0.333330000000

This shows $0.\dot{3}$ has been evaluated correct to 5 places of decimals, or to as many places of decimals as of any practical value. Immi is only one of the devices for limiting the evaluation; other devices in respect of other fractions, will be seen from Table XV. From this table it will be apparent that the lowest fraction envisaged is called "Thuti" which is equal to :—

$$\frac{1}{47} \times \frac{1}{45} \times \frac{1}{43} \times \frac{1}{41} \times \frac{1}{39} \times \frac{1}{37} \times \frac{1}{35} \times \frac{1}{33} \times \frac{1}{31} \times \frac{1}{29} \times \frac{1}{27} \times \frac{1}{25} \times \frac{1}{23} \times \frac{1}{19}$$

$$\times \frac{1}{17} \times \frac{1}{13} \times \frac{1}{9} \times \frac{1}{11} \times \frac{1}{7} \times \frac{1}{21} \times \frac{1}{320} \times \frac{1}{320}, \text{ which is}$$

$$= \frac{1}{542,\ 751,\ 901,\ 655,\ 154,\ 202,\ 906,\ 389,\ 494,\ 000,\ 000}$$

Evidently they used "Thuti" for evaluation $\frac{1}{47}$. By adopting the same method as shown for evaluation of $\frac{1}{3}$, it will be seen that $\frac{1}{47}$ = 6 Munthiri + 3 Kil-Kal + 1 Kil-Oruma + 1 Kil-Arakani + 15 Immi + 1 Anu + 3 Mummi + 6 Gunam + 9 Pantham + 2 Chinni + 3 Muthu + 5 Vargam + 7 Thayithanu + 12 Thai + 1 Tahikam + 26 Chinnam + 12 Varnam + 22 Kum-Kumam + 12 Kumalayam + 23 Pasi + 9 Mandalam + 25 Ninavu + 27 Rupam + 46 Thuti

This value in decimals is equal to 0.0212776936......But by the present method the value that is obtained is 0.02127659574. All the same the old Hindu method gives accuracy correct up to five places of decimals. If one takes the trouble of working out this problem in detail it will be seen that if their intention was to ensure an accuracy up to five places of decimals only, one could have stopped the process of division after "Anu" stage as the rest of the divisions and the rest of the Table XV are superfluous for the purpose. But they are useful for dealing with several intermediate evaluations between $\frac{1}{3}$ and $\frac{1}{47}$. These

evaluations obviously, as they can be judged from the Table in respect of fractions :—

$\frac{1}{43}$, $\frac{1}{45}$, $\frac{1}{39}$, $\frac{1}{37}$, $\frac{1}{33}$, $\frac{1}{31}$, $\frac{1}{29}$, $\frac{1}{23}$, $\frac{1}{19}$, $\frac{1}{17}$, $\frac{1}{13}$, $\frac{1}{11}$ $\frac{1}{9}$, $\frac{1}{7}$, $\frac{1}{5}$,

The denominators of all these fractions are prime numbers from 1 to 47. The evaluation of $\frac{1}{7}$ gives the result as 45 Munthiri, 228 Ki'-Munthiri and 12 Immi which is

$$= \frac{45}{320} + \frac{228}{320 \times 320} + \frac{12}{320 \times 320 \times 21}.$$

$$= 0.142857, \text{ exactly without any recurrence.}$$

Similarly the evaluation of $\frac{1}{13}$ gives the result as = 24 Munthiri, 19 Kil—Munthiri, 14 Immi, 3 Anu, 8 Mummi, 4 Gunam and 2 Pantham.

How did the Hindus carry out these long divisions ? They never did it by writing them down ; they did it all by mental calculation. To assist them to carry out the calculation, they had a complete system of multiplication Tables. These tables every school boy committed to memory, just the same as the ordinary multiplication tables. The Indians used to place great reliance on their memory, which appears to have never failed them. Their schooling consisted of committing to memory all recognised texts on any subject, Mathematics, Astrology, Astronomy, Medicine or Architecture. Dramas, historical works, and even Dictionaries they committed to memory. The proficiency in education used to be judged not by some chance questions which a scholar was able to answer at an examination, but by the ability with which one was able to quote or bring to use any text or knowledge without reference to books.

The ancient Egyptians had a system of dealing with fractions in which the fractions were reduced to a group with 1 as numerator.

It will be noticed from what has been shown above that the Hindu system was also based on reducing the fractions to a group with 1 as numerator. Benjamin Farrington states that the Egyptians expressed $\frac{2}{29}$ as $\frac{1}{24} + \frac{1}{58} + \frac{1}{174} + \frac{1}{232}$

The Hindu way of expressing $\frac{2}{29}$ is
= 2(11 Munthiri + 11 Kil—Munthiri + 5 Anu + 6 Gunam + 10 Pantham + 9 Chinni + 8 Muthu + 11 Vargam. + 22 Thaithanu + 11 Thai + 5 Tharkam).

By taking only the first three expressions of this evaluation the value comes to = 0.0689654.. correct to 6 places of decimals while the actual value of $\frac{2}{29}$ = 0.689655.... But according to the Egyptian method its value = 00 0689656. . .showing that it is slightly higher after 6 places of decimals. However both the Indian and Egyptian values are accurate for any useful purpose.

The Hindu system of evaluation may look very complicated when it is laid down on paper, but it is quite easy for any one who knows the tables by heart to do it mentally.

CHAPTER IX

The Sacrifical Altars

MAN FROM EARLY DAYS OF HIS ORGANISED LIFE APPEARS to have been propitiating God by sacrifices. The sacrifice, when it is stripped off its spiritual and ceremonial wrappings, is nothing but slaughter. The ceremonial sacrifices probably originated from man's disinclination to kill himself the animal, which he brought up and befriended. Ever since he began to show finer sentiments towards the animals, it became necessary to have a common place for sacrifice or kill and an individual specially commissioned for the purpose. The temples and the priests may have their genesis in this requirement of the commune. When the animal was sacrificed in the name of God or deity, its meat became sanctified, and partaking or eating of it became a sacrament. This practice is still going on, both among the civilised and the uncivilised in India. The aborriginies do it in the same way as their ancestors did thousands of years ago. The Vedic Aryans did it with great pomp and show, their descendants, the high class Brahmins, at any rate a section of them, do it even now on the quiet and at times in the dead of night. The "Pahan" the elected head of the Oraon village, do the killing with the assistance of his right hand official, the "Mahatoe", in the "Sarana", the dedicated place for it in the outskirts of the village. Before he kills he

prepares a bit of ground with his own hands, which appears to have paved the way for sacrificial altars. In litany, for the sacrifice, he even appears to have taken the lead. He invokes his gods to give him and the people under his care prosperity, timely rains, good harvest and safety from wild animals. The gods he invokes are three, (i) the "Grama Devata", the Friend and guardian of the village, (ii) the "pithrus", or the Spirits of the ancestors, and (iii) the "Bonga", or the Spirit of the Mountains. If one is to judge from the opening verses of the Rig Veda, the Vedic Aryans too followed this procedure; for they at their sacrifices invoked the aid of "Varuna" the friend, companion and comforter of their wandering days, presumably on the waves or ocean; "Mitra", probably the spirits of their relations, for Mitra in Sanskrit means "Bandu' or relation; and "Soma", the god of the mountains. Their prayers on these occasions are also the same in essence as those of the Oraons. The first development in alter construction appears to have been to cover the prepared ground with mud and cow-dung, as it is done even now at the marriage ceremonies and such like by the civilised Hindus. But thousand of years ago the Vedic Aryans constructed alters with brick and mortar in true geometrical shape and form with mathematical accuracy. This practice was in existence even earlier than the days, during which the Vedas were compiled by Vyasa. Bharata, the great king after whom a great part of India was once called the Bharata-Varsha (the empire of the Bharata), invited eminent sages to his court from all over the country and performed all the sacrifices one after the other. Probably he might have been influenced by his upbringing in the hermitage of the sage Kanwa, the foster father of his mother Sakuntala, the wife of King

Dushanta, the hero of the world famous Drama, the Sakuntala or the Lost Ring. The King Bharata's time was well before 1,600 B.C., and probably about 2,000 B.C. Since then every king of any importance performed great sacrifices, especially at the time of their coronation, or after great victories. The large scale preparations of the Asva-Medha (Horse sacrifice) performed by Yudhishtar, after the battle of Kurukshetra, is thus described in Mahabharata: :—

"Brahmins versed in sacrifices, cunning architects of fame, builders of each various alters with the son of the Pritha came. And upon a level green sward and measured forth the sacred site. Laid it out with halls and pathways for the sacrificial rite. Mansions graced with gem and jewel round the bright arena shone. Palaces of golden lustre glinted in the morning sun, guilt and blazoned with devices, lofty columns stood around, graceful arches gold surmounted spanned the consecrated ground, come to view Yudhistir's Yajna and to bless Yudhistir's name".

The verses are from R.C. Dutt's Mahabharata. From these the magnitude of the work and what the Silpis had to do on occasions like these can more or less be understood. The Silpis took advantage of such circumstances, and in the construction of the alters, though presumably for sacrifices, they revised their mathematical knowledge, tested their formulae, instructed the pupils and demonstrated their geometry and applied mathematics. It is often said that Geometry became essential to the Hindus on account of their sacrificial rites; this, to say the least, is putting the cart before the horse. They introduced alters with hidden mathematical secrets to perpetuate science in by-gone days when books were none and the

learning was confined to a few. If it were otherwise, all the sacrifices and "Poojas" (worship with offerings, words, and mental abstraction) that are performed should be of no sanctity and purpose as they are not performed on Mathematically accurate altars.

It was shown in Chapter III how their survey system became altars for sacrifice and worship; in like manner their geometry and applied mathematics became altars for special sacrifices. There are books that give information about the altars and their construction, books like Yajur Veda Samhitas, Brahmanas and Sulva Sastras. The Sulva Sastras are the latest of them. Though four Sulvas namely, Apastamba, Manava, Maitrayana, and Varaha are well-known, there were others which appeared to have completely vanished. The Sulvas can be considered as treatises on Hindu Geometry. Sulva literally means the science of measuring or measurement, like its European counterpart Geometry. The Samhitas according to Indian scholars are as old as 3,000 B.C., and Brahamanas (especially Satapata Brahmana) dates from 2,000 B.C. From these it will be seen that the Hindus probably in a limited way, developed geometry in all its three aspects, plane, solid and co-ordinate, at a very early period.

These treatises speak of many altars for different sacrifices, some are for special occasions, while the others are for daily use. But each one appears to have its own hidden secrets, which probably have been imparted only from the master to the deciple or father to son. However, to judge the nature of the secrets contained in them the following four altars may be considered:—

(1). Ahavaniya.

(2). Grahapatya.
(3). Daksina or Dakshina, and
(4). Mahavedi or Saumiki.

The first three are called Nithyagnis, indicating that they should be constructed and worshipped daily by every 'Grahasta', family man, while Mahavedi is for special occasions. Ahavanya is a square of given sides. The Grahapatya is a circle whose area is equal to that of Ahavaniya square. Dakshina is a semi-circle, whose area is equal to either of the two above. Mahavedi is a trapezium of given dimensions, whose area should be equal to three times the area of a second trapezium known as Soutramani and equal to nine times the area of another trapezium known as Paitraki.

It is obvious that no circle of a given area can be drawn without knowing the value π, or the ratio between the circumference and the diameter of the circle; and no semicircle of this kind can be drawn without knowing the value of the $\sqrt{2}$. Neither of these value are given in this connection, and the investigator therefore is left to guess.

Let us first investigate what would have been the value of π used by the ancient altar builders. The oldest Hindu value is supposed to be the one given by Baudhayana. This value is quoted thus :—

"If you wish to circle a square, draw half the diagonal about the centre towards the east-west line, then describe a circle together with one-third of that which lies outside (the sqaure).

In Diagram (13) Let ABCD represent the Ahavaniya Square of sides one Vyama each. Let OA be half the diagonal, which when rotated to the east from the centre O gives OF = OA. Let E be the point where the east-west line cuts AD, the side of the

square. Divide EF into three parts, making EG = HG = HF. Then OG gives the radius of the required circle.

$$
\begin{aligned}
\text{Now } OG = &= OE+EG \\
&= OE + \tfrac{1}{3}EF \\
&= OE + \tfrac{1}{3}(OF\text{-}OE) \\
&= OE + \tfrac{1}{3}OF\text{-}\tfrac{1}{3}OE \\
&= \tfrac{2}{3}OE + \tfrac{1}{3}OF \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(A).
\end{aligned}
$$

In the square ABCD of 1 unit sides the diagonal AC = $\sqrt{2}$

$$\therefore\quad OA = \tfrac{1}{2}\sqrt{2} = OF \text{ ; and } OE = \tfrac{1}{2}$$

By substituting these values in the equation (A)

$$
\begin{aligned}
OG &= \tfrac{2}{3} \times \tfrac{1}{2} + \tfrac{1}{3} \times \tfrac{1}{2}\sqrt{2} \\
&= \tfrac{1}{3} + \tfrac{1}{6}\sqrt{2}
\end{aligned}
$$

Now taking $\sqrt{2} = 1 + \frac{1}{3} + \frac{1}{3 \times 4} - \frac{1}{3 \times 4 \times 34} = \frac{577}{408}$.

We get $OG = 0.33333333 + 0.2357026 = 0.5690359$

$\therefore$ The diameter of the circle $= 2 \times OG = 2 \times 0.560359 = 1.1380718$

As the area of the circle = area of the square

$$\frac{\pi}{4} d^2 = 1 \times 1 = 1, \text{ where d is the diameter,}$$

$$\therefore\ \pi = \frac{1 \times 4}{d^2} = \frac{4}{(1.138)^2} = \frac{4}{1.29501} = 3.088$$

This value of π is certainly too small. Is it likely that the ancient altar builders have used such an inaccurate value? The ancient Hindus according to Laplace had the reputation of recording the movements of the planets correct to a second, an opinion supported by Bailey and Playfair. Would it have been possible for them to do such calculations with such inaccurate equipment as this?

This value of π is of course, based on the above quoted rendering of the Baudhayana Text.

The rule of Baudhayana does not indicate that the construction was intended for describing a circle equal in area to that of a square. A circle can be equal to the square in respect of the perimeter as well. If Baudhayana's rule was intended for the purpose of drawing a circle whose circumference is equal to the perimeter of the square, and the chord which lies outside indicates OE, along the east-west line, the following result, which is unexpected, is obtained.

By extending OB, one-third of its own length to G, makes OG $= \frac{4}{3}$ OE, and by drawing the circle with OG as radius and when π_p is the ratio of the diameter of the circumference in respect of the perimeter.

$\pi_p \times d = 4$ as the side of the square is 1, and $d = \frac{4}{3}$

$$\therefore \pi_p = \frac{4 \times 3}{4} = 3.$$

This then might be the value of $\pi = 3$, which is often quoted against the Hindus and the ancient Jews. The pillars at the porch of King Solomon's temple are said to have had a circumference of 12 cubits, with a diameter of 4 cubits. However, there is every reason to conclude that the Silpis were concerned more with perimeters than with areas.

Another value of π, which is attributed to the Hindus, $= \sqrt{10}$. Brahma Gupta used this in 628 A. D. but it was a very inconvenient figure to be used by practical Silpis of ancient days. For by applying this value in the conversion of Ahavaniya Square into Garhapathya circle, it will be apparent that

$d = \sqrt{\dfrac{4}{\pi}} = 2 \times \dfrac{1}{\sqrt{\pi}} = \dfrac{2}{\sqrt[4]{10}}$; a value which cannot but be considered as inconvenient.

There is but one value of π which gives a nice round number for setting out the altar. This value of π = $(\frac{16}{9})^2$

The area of the Ahavaniya Square. $= 1 \times 1 = 1$ Square Vyama.
$= 4 \times 4 = 16$ Square Kols.

$\therefore \frac{\pi}{4} \times d^2 = 16$ square Kols, where d is the diameter of the Garhapathya circle ;

then if $\pi = \left(\frac{16}{9}\right)^2, d^2 = \frac{16 \times 4 \times 9 \times 9}{16 \times 16.}$

.. $d = \frac{9}{2} = 4\frac{1}{2}$ Kols, a measure, which could be used with greater ease for construction.

This value of π is given in the Rhind Papyrus, discovered by Rhind, a Russian, among the ruins of Egypt in the 19th century A.D.

This Papyrus was written probably in 1650 B. C., but copied from an original of the time of Amenemhet III (of the 12th Dynasty) who reigned from 1849 to 1801 B.C. How the ancient Egyptians arrived at this value is not known. However it is presumed that they had taken the side of the equivalent squares as $\frac{8}{9}$ths of the diameter of the circle. In fact it is exactly what is seen from the construction of the Garhapatya circle, for when the diameter of the circle is $4\frac{1}{2}$ Kols, the side of the square is 4 Kols, or when the diameter is 1 Vyama, the side of the square is $\frac{8}{9}$ ths Vyama. It is not likely that they troubled themselves to divide one into 9 equal parts ; most probably they might have arrived at the result by taking the diameter of the cirlce $1\frac{1}{8}$ times the side of the square.

If the ancient Silpis used this rule, why no such rule is forthcoming ? The Silpis' interest in eqivalent areas must have been superceded by their preoccupation with the perimeters, or this rule might have been kept as one of those great secrets, unwritten, but transmitted by word of mouth only. Unrecorded secrets are found throughout the length and breadth of India. The properties of

herbs, are handed down by ancestors to successors only. So is the case with trade secrets. In a certain part of Travancore, there is a family of brass-smiths, who know the formula for making fine loooking-glass from brass, the secret of which they have not divulged, so far, to anybody outside the family.

If the value of π used by the ancient altar builders in India were the same used by the ancient Egyptians, before 1800 B. C. does it not show a close contact between the two races? Or it might even be that one was influenced by the other. In Egypt as well as in India, mathematical secrets, like all other scientific knowledge, were in the custody of the priests. When a Nambuthiri Brahmin from Malabar coast is properly robed for the performance of certain religious rites, he would invariably remind one, of the men in ancient Egyptian pictures. If this value of π were borrowed from the ancient Egyptians, would the orthodoxy of the Hindus have allowed them to incorporate it in their most sacred daily rites? However according to Oldenberg these altars are earlier than the Rig Veda.

The Pyramids of Cheops and Sneferu, constructed on a common geometrical pattern have the ratio of the per meter to the height as the same ratio of the circumference to the radius of the circle, which is 44 is to 7; from this some are inclined to think that the Egyptians value of $\pi = \frac{44}{2 \times 7} = \frac{22}{7} = 3\frac{1}{7}$. Some even go to the extent of suggesting that one of the motives for the construction of the pyramids was to establish the value of $\pi = 3\frac{1}{7}$. The pyramids were constructed sometimes between 3000 B.C. and 2500 B. C. The value of π as $3\frac{1}{7}$ is a better value than $(\frac{16}{9})^2$. Is it probable that the value of π as $(\frac{16}{9})^2$ shown in the Rhind Papyrus is one even earlier than the Pyramidal value?

The Pyramidal value of π is the same as the one attributed to Archimedes. Archimedes was a native of Syracuse, educated in the University of Alexandria, which was established by Ptolmey about 300 B. C. Archimedes was born in 287 B. C. and killled by a Roman soldier in 212 B. C. while making some geometrical figures on the sand. He proved the following properties of the circle, among the rest :—

(1) The area of the circle is the same as the area of a right-angled triangle whose sides are respectively equal to the radius and the circumference of the circle.

(1) π is less than $3\frac{1}{7}$ and greater than $3\frac{10}{71}$.

He arrived at the vaule of π by inscribing and circumscribing regular polygons of 96 sides in and about the circle. The idea of inscribing the polygon does not appear to have originated by Archimedes, for it is stated that Antiphon, a contemporary of Socrates (469-399 B.C.) tried the method of inscribing a regular polygon in a circle with the idea of arriving at a polygon "the sides of which would, owing to their smallness, coincide with the circumference of the circle". Probably Archimedes might have used the methods of Antiphon, and established the value of π hidden in the pyramids, unknowingly. Archimedes was not quite satisfied with the value of π less than $3\frac{1}{7}$ and greater than $3\frac{10}{71}$ and made another more accurate calculation, which unfortunately has not been recorded properly. It appears that the Archimedian value of π was known to the Silpis of South India, whether they came by it independently or got it through the traders who came to Musuris (now Crangnore) and other ports on the Malabar coast. However, it might be, there is some indication that the Hindus used this value of π to divise means to test the suitability of the measurements.

For the construction of the Semi-circular Daksina Alt r, which was to be equal in area to the Ahavaniya square, an accepted values of $\sqrt{2}$ was essential. Let us see wh t value of $\sqrt{2}$ the ancient Altar builders used.

The irrational nature of $\sqrt{2}$ gave a great shock to the ancient Greeks, for it gave contradiction to their pet theories. They hid the matter for sometime. The ancient Silpis seem to have tackled the problem with a measuring rod. Baudhayana (2000 B. C.) gives the following rule for extracting the square root of 2.

"Increase the measure by its third part, again by the fourth part less by the thirty-fourth part of itself."

This rule is also given by Apastamba (4th o: 5th century B.C.); but Thibaut does not credit Baudhayana or Apastamba, in fact any Hindu, with the ability of extracting the square root, accurate to five places of decimals which in fact is what this rule leads to. He suggests that they arrived at this by process of trial and error, while others say that they got it through partial fractions. However it might be, they used a value of $\sqrt{2}$, accurate to this extent.

The Baudhayana value of $\sqrt{2} = 1 + \frac{1}{3} + \frac{1}{3\times 4} - \frac{1}{3\times 4\times 34}$.

The numerals used in this equation give a direct clue to its origin, provided one is conversant with the Hindu table of measurements.

Let us renew our acquaintance with their measuring rod. It has already been shown what were the original divisions on it, and how a new division called Yoni was introduced. Let us consider the relevant portion of the rod:—

8 Yukas	=	1 Yava.
8 Yavas	=	1 Angula.
8 Angulas	=	1 Yoni.
3 Yonis	=	1 Kol.

Now if a square with sides of one Kol is taken and the diagonal of it is read by a measuring rod calibrated according to the above sub-divisions, the readings will approximately be :—

1st:	1 Kol	=	1 Kol.
2nd:	1 Yoni	=	$\frac{1}{3}$ Kol.
3rd:	2 Angulas	=	$\frac{1}{3 \times 4}$ Kol.
Total reading		=	$1 + \frac{1}{3} + \frac{1}{3 \times 4}$.

But with an accurately calibrated measuring rod it will be found that the above reading is slightly in excess. Then the problem becomes how to express this excess. The ancient Silpis seemed to have looked at the reading already made, and expressed the excess in terms of it. For

1Kol + 1 Yoni + 2 Angulas = 34 Angulas.

and the excess was expressed in terms of 34, namely $\frac{1}{12}$ of $\frac{1}{34}$, thereby giving the reading as :—

$$1 + \frac{1}{3} + \frac{1}{3 \times 4} - \frac{1}{3 \times 4 \times 34}$$

It is obvious that the diagonal of the square of 1 unit sides is $\sqrt{2}$.

Therefore $\sqrt{2} = 1 + \frac{1}{3} + \frac{1}{3 \times 4} - \frac{1}{3 \times 4 \times 34}$

Converting the factors into decimals :

$\sqrt{2} = 1.41421568$, while the modern value of $\sqrt{2} = 1.41421356$ showing the Silpi was accurate to 5 places of decimals only.

A correction to the above value was made by Rama (A.D. 750) as;—

$$\sqrt{2} = 1 + \frac{1}{3} + \frac{1}{3 \times 4} - \frac{1}{3 \times 4 \times 34} + \frac{1}{3 \times 4 \times 34 \times 34} - \frac{1}{3 \times 4 \times 34 \times 33}$$

$$= 1.41441350$$

which is slighily less after 6 places of decimals.

When these values of $\sqrt{2}$ are applied to the squares of greater dimensions than unity, the measurement of the diagonals becomes

less accurate. Take, for instance, the case of Ahavaniya Square, whose sides are one Vyama or 4 Kols each, then the diagonal of the square is $4\sqrt{2}$ which according to Baudhayana rule is 5.65686272 Kols, but it should, according to the present methods, be 5.65685424 there by reducing the accuracy to 4 places of decimals.

It appears that some general methods for extracting the square roots were known to the Hindus. A rule is found in Bakhshali manuscript, a document written on Birch-bark, or Bhoja patra, and unearthed by a tenant, while digging a ruined stone enclosures on a mouud near Bakhshali in the north-west part of India, in 1881. This rule, says G. R. Kaye, a great critic on Hindu achievements, is neither connected with continued fractions nor with the so-called Pellian equation.

The rule is:—

" In case of a non-square (number) subtract the nearest number; divide the remainder by twice (the root of that number). Half the square of that (that is, the fraction just obtained) is divided by the sum of the root and the fraction and subtract: (this will be the approximate value of the root) less the square (of the last term)."

The evaluation of the diagonal of the Ahavaniya square according to this formula is 5.65685425, showing accuracy to six places of decimals. But the process is such, that if further accuracy is required, it can be extended further.

The age of Bakhshali manuscript, according to Bibhuthi Bhushan Datta is about 200 A. D., though Kaye is of opinion that it is of a later date. But whatever may be its date, there is no reason to conclude that this rule was not known to the Hindus earlier than the date of Bakhshali manuscript; it might have been of a much earlier date. However it gives an insight into the principles

on which the Hindu mathematicians worked. The converse of this rule is given by Brahma Gupta, probably in 628 A. D.

Bhaskara (1150 A. D.) gives another rule for the extraction of the square root, in his famous book called "Lilavati". It runs as follows:—

" Multiply the quantity, whose square root cannot be found, by any large square number, take the square root of the product leaving out of account the remainder—and divide by the square root, of the multiplier".

The accuracy of this process depends on the magnitude of the " large sqaure number" with which the quantity is multiplied and divided.

Take the case of $\sqrt{2}$. When it is multiplied say by 10,000

$$\frac{\sqrt{2 \times 10{,}000}}{\sqrt{10{,}000}} = \frac{\sqrt{20{,}000}}{\sqrt{10{,}000}} = \frac{\sqrt{19{,}881}}{\sqrt{10{,}000}} = \frac{141}{100} = 1{\cdot}41$$

giving accuracy only to two places of decimals. If the square number is 1,000,000 greater accuracy is obtained.

Mahavedi, or Saumiki Vedi, appears to be a very important altar, if one is to judge from the details and references given by many authors. The earliest mention to this altar is found in Yajur Veda (2,000 B. C.) and the details of its construction appears first in Satapatha Brahmana (1,000 B.C.) and since then authors of rituals or science appear to have dealt with the subject elaborately, but without unfolding the mathematical secrets underlying the construction; they are prepossessed with the ritualistic aspect. Maha-Vedi is a regular isosceles trapezium, the construction of which would not give much headache to a school boy of to-day. Some of the details given by the authors may look very superfluous; but it is actually these details that would give us valuable information.

The base of the trapezium is given as 30 Prakramas, the face (or opposite side) is 24 Prakramas and the altitude is 36 Prakramas. Parkrama appears to be a measure like feet or strides. The upright is laid out with true orientaion towards the east. The base is made, truly perpendicular after checking the perpendicularity by laying out a right-angled triangle of sides 3, 4 and 5 units. Apastamba about the middle of the first millinium B. C., gives four constructions, to draw out the trapezium on the ground, any one of which would have been sufficient for the purpose. The different constructions appear to have some other significance than merely drawing the diagram. These constructions as given by B. Dutta, in his Science of Sulba are :—

Construction : (a). " The diagonal of a rectangle whose sides are 3 and 4 Prakramas is 5. With these increased by 3 times (give) the eastern corner of the Vedi with these increased by four times (give) the western corners".

Construction (b). The diagonal of a rectangle whose sides are 5 and 12 is 13. With them the eastern corners of the Vedi. With them increased by twice themselves, the western corners.

Construction (c). The diagonal of a rectangle whose sides are 8 and 15 is 17, with these cords the two western corners of the Vedi; the diagonal of a rectangle of sides 12 and 35 is 37; with these cords the western corners.

For these constructions see Diagram (14) – (a), (b), (c).

These constructions appear to be instructions about the properties of right-angled triangles more than directions to construct the Vedi. Evidently Apastamba did not make them into propositions

like Euclid had done. The right-angled triangles used in these constructions and their properties are:—

$$3^2 + 4^2 = 5^2 \ldots\ldots\ldots\ldots\ldots (1).$$
$$12^2 + 16^2 = 20^2 \ldots\ldots\ldots\ldots\ldots (2).$$
$$15^2 + 20^2 = 25^2 \ldots\ldots\ldots\ldots\ldots (3).$$
$$5^2 + 12^2 = 13^2 \ldots\ldots\ldots\ldots\ldots (4).$$
$$15^2 + 36^2 = 39^2 \ldots\ldots\ldots\ldots\ldots (5).$$
$$8^2 + 15^2 = 17^2 \ldots\ldots\ldots\ldots\ldots (6).$$
$$12^2 + 35^2 = 37^2 \ldots\ldots\ldots\ldots\ldots (7).$$

It appears that it was for keeping thus these right-angled triangles and their properties on record that this Vedi had been designed, though these do not include all such righ angled triangles, which ancient Hindus had known, for Sir Thomas Heath gives an additional rightangled triangle (7, 24, 25) from Baudhayana Sulva Sastra. If the object of this Vedi had been for the preservation of these theorems, it may not have been possible to devise better means than including it in an altar for worship, especially in an age when books were scarce and their safety was not sure. The great library at Alexandria with innumerable volumes was destroyed by fanatic Christians, whose library in turn was destroyed by the Mahomedan conquerors. Then in ancient days they wrote few books; even Pythagorus did not write any book in his time, the first book about the discoveries and teaching of Pythagorus was published by Philolaus, about 370 B. C., after the dispersal of the Pythagorian school.

Pythagorus is said to have proved the properties of the right-angled triangle; when he proved that the square on the hypotenuse of a right angled triangle was equal to the sum of the squares on the

other two sides, he was so overjoyed, that he had an oxen killed for a grand feast, although he was known to be a vegetarian.

However, according to Ball,* the proof of Euclid's propositions 47 and 48, Book I are Euclid's own invention. The Hindus do not appear to have given the proof of the properties of the right-angled triangle; for the Hindus, Mathematics was not an abstract subject, and they busied themselves with the more practical side of it, such as, zero, place value notation, compound interest, flexible measurements, etc.

The Theorem, known in the name of Pythagorus was his own or not, a statement by Apuleius is worth mentioning. He states that Pythagorus visited Egypt, learned magic, arithmetic and geometry from the priests, then when he was taken away from Egypt, as a prisoner by Cambyses, King of Persia, in his train to Babylonia, he learned the Chaledean Mysteries, and then when he was taken to Persia, he became a disciple of Magi, Zoroaster, and visited the Brachmanes of India. If Pythagorus had visited the Brachmanes or Brahmins of India, he must have done so, sometime about the middle of the 6th century B. C. for he was born in 582 B. C. and died in 507 B. C.

Did Pythagorus visit India before or after Apastambha ? The nature of the intellectual development in India, at the time of Pythagorus's visit may be somewhat guessed from the following events. Panini, the great Grammarian, who is still the authority on Sanskrit Grammar, perfected his work in 700 B. C. Buddha was born at Kapilvastu in 557 B. C. Maha Vira Vardhamana Jnanaputra, the last of the Jain saints died in 527 B. C. Interest in India among the outsiders was rampant. Darius Hystaspes sent his General, Skylax, to explore the course of the Indus in 515 B. C.

* Short Account of the History of Maths.

It appears that the Maha-Vedi diagram was not merely for the purpose of maintaining the rational right-angled triangles and perfect squares. The diagrams that would give squares of numbers could be exploited for finding the square roots. It is seen from the constructions that it is the points on the upright that are giving the squares. Hence the points on the upright could be made to yield secrets of the square roots as well.

Take the Trapezium ABCD, Diagram (15) with unit face and other dimensions shrunk accordingly.

Let the face $AD = 1$, with $AE = ED = \frac{1}{2}$

Base $BC = 1\frac{1}{4}$

and upright $EW = 1\frac{1}{2}$

Divide EW into three parts

making $EF = FG = GW = \frac{1}{2}$

Join AF and DF, AG and DG.

also AW and DW

In the right angled triangle AEF

$AE = EF$ each being $= \frac{1}{2}$

$\therefore \quad AE^2 + EF^2 = AF^2$

$$\text{or} \quad AF = \sqrt{AE^2 + EF^2}$$

$$= \sqrt{(\tfrac{1}{2})^2 + (\tfrac{1}{2})^2} = \sqrt{\tfrac{1}{4} + \tfrac{1}{4}} = \sqrt{\tfrac{2}{4}}$$

$$= \tfrac{1}{2}\sqrt{2}$$

$$\text{or } AF + DF = \sqrt{2}$$

Thus the diagram gives a graphic representation of the Value of $\sqrt{2}$.

Now take the right angled triangle AFG. It is obvious that

$AE^2 + EG^2 = AG^2$

$$\begin{aligned} \text{or} \qquad AG &= \sqrt{AE^2 + EG^2} \\ &= \sqrt{(\tfrac{1}{2})^2 + (1)^2} \\ &= \sqrt{\tfrac{5}{4}} \\ &= \tfrac{1}{2}\sqrt{5} \\ \text{or} \quad AG + GD &= \sqrt{5} \end{aligned}$$

Similarly it will be found that $AW + WD = \sqrt{10}$

Most probably the Hindu Value of π as $\sqrt{10}$ might have originated graphically in this manner. It should not be forgotten that their original value of $\sqrt{2}$ was also derived from a graphical method.

It appears that they checked this value of π by other means. For in Surya Pragnapti (500 B. C.) the circumference of a circle whose diameter is 99, 640 yojanas is given as 315,089 yojanas and a little over; and that of a circle of a diameter 100,660 yojanas as 318,315 yojanas and a little less.

The respective values of π obtained by these examples are :—

$$\text{(a) } \pi = \frac{315{,}089 + \text{a little}}{99640} = 3.1622742 + \frac{\text{a little}}{99640}$$

$$\text{(b) } \pi = \frac{318{,}315 - \text{a little}}{100660} = 3.1622789 - \frac{\text{a little}}{110660}$$

Therefore, the value of π lies between 3.1622789 and 3.1622742. It will be seen that the value π that comes between these two limits is $\sqrt{10}$, which is $= 3.1622776$.

A thousand years later the value of π as $\sqrt{10}$ was confirmed by Paulisa (500 A. D.), for in Paulisa Siddhanta the value of π given thus :—

" The square root of the tenth part of the square of the circumference which comprises 360 parts is the diameter".

That is—

$$\sqrt{\left(\tfrac{1}{10} \times \text{circumference}\right)^2} = \text{diameter.}$$

$$\therefore \frac{\text{circumference}}{\sqrt{10}} = \text{diameter.}$$

$$\therefore \frac{\text{circumference}}{\text{diameter}} = \sqrt{10} = \pi$$

But Paulisa here brings in a new element, namely the division of the circumference of the circle into 360 parts. Was he influenced by Archimedes in this respect? Archimedes circumscribed and inscribed polygons of 96 sides to get the values for π. However, it appears that while Paulisa adhering to the value of π as $\sqrt{10}$ was endeavouring to give $\sqrt{10}$ a better value.

Now draw the circle AFD, with E as centre. Then a glance at the diagram would suggest one that half the circumference AFD has been stretched along AW. It was stretching out the circumference along a base line, or rolling the circle over a tangent, that Archimedes proved that the area of a circle was equal to the area of a rightangled triangle, whose sides were respectively equal to the radius and the circumference of the circle. But here the area of the semi-circle is not equal to the area of the triangle

The area of the semi-circle $= \frac{1}{2} \times \frac{\pi}{4} \times 1^2 = \frac{\pi}{8}$

and the area of the triangle AWE $= \frac{1}{2} \times \frac{1}{2} \times \frac{3}{2} = \frac{3}{8}$

If the area of the semi-circle were equal to the area of the triangle, then π would be equal to 3. This is Baudhayana's value of π, when the circumference of the circle is equal to the perimeter of the square. It may be that the stretching out the circumference was not done for obtaining the value of π, but to preserve

on record a graphical value of π as $\sqrt{10}$, a value which they might have got through other sources.

As points F, G and W on the line EW, in Diagram (1) enabled us to get the roots of 2, 5 and 10, the same line can be made to yeild the graphical values of all other numbers from 0 to 10. The only difficulty will be to find the corresponding points on EW. Suppose the value of $\sqrt{3}$ is required. Let x be the point that gives the value of $\sqrt{3}$.

From the right-angled triangle E X D, it is evident that

$$EX^2 = AX^2 - AE^2$$

By our suppositionn $AX^2 = (\frac{1}{2}\sqrt{3})$

and $AE^2 = (\frac{1}{2})^2$

therefore $EX^2 = (\frac{1}{2}\sqrt{3})^2 - (\frac{1}{2})^2$

$= \frac{1}{4}(2)$

therefore $EX = \sqrt{\frac{1}{4}(2)} = \frac{1}{2}\sqrt{2}$.

We already know the value of $\frac{1}{2}\sqrt{2}$, as AF. Therefore mark off a length EX along EW, which will give the required point X. Then AX + DX will give the value of $\sqrt{3}$. In like manner the root of any number up to 10 can be found grap! ically. But could we credit ancient Hindus with graphical methods ? A true understanding of their system will show that they got graphical values first and fine values worked out afterwards. This will b seen from the manner in which they tried to arrive at an accurate value for $\sqrt{3}$.

As it has been stated before there is a diagram named Soutramani that should be derived from Mahavedi, and another one Paitraki to be derived from Soutramani and the area of Soutramani is to be $\frac{1}{3}$ the area of Mahavedi and area of Paitraki is to be $\frac{1}{3}$ the area of Soutramani or $\frac{1}{9}$ the area of Mahavedi.

To make the area of Soutramani equal to $\frac{1}{3}$ the area of Mahavedi, the dimensions of the latter has to be shrunk. Similarly to make the area of Paitraki to be $\frac{1}{3}$ the area of Soutramani, it has also to be shrunk.

Now the dimensions of the Mahavedi are face 24, base 30, and the upright 36. Therefore its area $= 36 \times \left(\frac{24+30}{2}\right) = 36 \times 27 =$ 972. The area of Paitraki should be $\frac{1}{3}$ of $324 = 108$.

Let x be the ratio of shrinkage, then the area of Soutramani $36x \times 27x$ should be $= 324$.

$$\text{therefore} \quad x^2 = \frac{324}{36 \times 27} = \frac{1}{3}$$

$$\text{therefore} \quad x = \sqrt{\tfrac{1}{3}} = \frac{1}{\sqrt{3}}.$$

And the area of Paitraki

$$36\,x^2 \times 27\,x^2 \text{ should be } = 108.$$

$$\therefore x^4 = \frac{108}{36 \times 27} = \frac{1}{9}$$

$$\therefore x = \frac{1}{\sqrt{3}}$$

Therefore it is evident that the rate of shrinkage or reduction cannot be found without having at hand a value for $\sqrt{3}$; and without the possession of this value the Soutramani and Paitraki cannot be constructed and one cannot get all the benefits, that are held out in the Sastras to those who accomplish the construction, such as prosperity, victory, health in this world or in the next one. There is no indication from any source what was the value of $\sqrt{3}$, the Silpis used for this purpose. Sure they had a value, which the writers of the Sulvas had not known

or they thought it was sacrilegious to let the vulgar public know. However, the way they found the value was apparently a method of trial and error, for it is evident from the stipulation that the dimensions of Paitraki should be such as to yield its area $\frac{1}{3}$ of Mahavedi and the area of Paitraki should be such as to make it equal to $\frac{1}{9}$ of Mahavedi. As we are not in possession of the exact value of $\sqrt{3}$, which they got from the graphical construction in Mahavedi let us take some approximate values for $\frac{1}{\sqrt{3}}$ which the Hindus have on record.

Bihhutibhushan Datta gives an approximate value of $\frac{1}{\sqrt{3}}$ as 0.5784. . . .a value he deduced from certain equivalent measurements which an ancient writer, Dwarkanath Yajava recorded

Now as the upright of the Maha Vedi = 36 and the average of its base and face = 27, the upright of the Southramani Vedi should be $= 36 \times x = 36 \times 0.5784 = 20.8224$ and the average of its base and face should be $= 15.6168$, and therefore the Area of Southramani will be $= 20.82 \times 15.61 = 325.00$, while the required value should be $= 324$. Therefore the value of $\frac{1}{\sqrt{3}}$ taken above is too high. Let us now take the present value of $\frac{1}{\sqrt{3}}$ $= 0.5773$. . . . (correct to four places of decimals). Then the upright of the Southramani will be $= 20.7822$ and the average of the base and face $= 15.5871$, giving its area $= 323.9435$. . . . which is obviously slightly less than the area required by the Sastras. Hence it is abundantly clear that the altar builders envisaged an area even more accurate than the one we could get by working with an accuracy up to four places of decimals. Presumably

the dimensions they envisaged for their Paitraki were :

Face	=	8	
Base	=	10	
and upright	=	12	
giving the area	=	108	Prakramas

In the light of this interpretation, the names given to these respective Vedis, assume a great deal of importance. If Paitra of Paitraki stands for Poutra, (Poutra means grandson), grandson of the Maha-Vedi, Maha or grand indicating the second degree of parentage; and if Soutra-Mani stands for Sutra-mani, it would mean the jewel of Sutras or the greatest of the clue, or the Vedi or diagram which contains the greatest secret, namely, the solution of the value of $\sqrt{3}$.

Paitra must have been the Prakrit for Poutra, and Soutra that for Sutra. The Prakrit is the language from which the Sanskrit of Samskrita has been derived. Sanskrit or Samskrita, as the word itself indicates, is that which has been purified, as the metal from the base, the purifier, or the fire being Panini, the great Grammarian, who might have laid down about 700 B. C. what should be the "King's" Sanskrit. But Prakrit is considered by some as the corrupted form of Sanskrit, which to say the least, is putting the cart before the horse. Can Chaucer's English be claimed as the corrupted form of King's English ?

The ancient Egyptains, like the Hindus, have handed down a a trapezium. The Egyptian Trapezium, as is given in the Rhind Papyrus has the base and the opposite sides 6 and 4 units, while the "Myrt" or the upright is 20 units. Sir Thomas Heath says that this trapezium "seems to have been Isosceles", and he comments

on the disproportionality of the upright. If this was intended to be Isosceles, its resemblance to the Indian Trapezium is most striking.

It has been shown that the dimensions of the Paitraki trapezium might have been face 8, base 10, and upright 12. Half of this trapezium has 4 units for the face, and 5 units for the base and 6 units for the upright. Thus the face of this diagram becomes the same as that of the Egyptian Trapezium, though the base and upright are different. By superimposing the one on the other, the close resemblance between the two becomes most obvious. See diagram (16)

The Egyptian diagram looks like an elongation of the Indian or the Indian a shortened and modified form of the Egyptian. The Egyptian diagram lends iteslf for graphical determination of further roots, i.e., $\sqrt{17}$,and $\sqrt{26}$ etc. but it does not contain a clue or "sutra" for the accurate determination of $\sqrt{3}$. Probably the likeness of the two diagrams is mere accidental.

The significance of the Hindu diagrams has not been fully gone into, there are other features which need further exploration. For instance, the first act in setting out the Maha-Vedi was to fix a Pole 3 prakramas away from the starting point. What was it for? Was it for merely fixing the base, or was it an indication to the concealment of some spherical or cubical problems? Whatever it might have been from what has been stated above, the mathematical equipment of the ancient Silpis can more or less be gauged.

CHAPTER X

Town-Planning

TOWN PLANNING WAS AN OLD INDIAN ART, WHICH THE SILPIS appear to have converted into a Science. The genesis of the Indian Town Planning used to be attributed to the Indo-Aryans. But it has become apparent now that the Aryan invaders did not bring any town planning with them, and long after their entry into the country, they were living in bamboo huts in small "busties" (hamlets). On the other hand the excavations at Mohenjo-daro have revealed that well laid out towns were in existence, at any rate, in fourth millennium B. C. From the regularity with which the city of Mohenjo-daro was divided up and the successful alignment of the streets, it is evident that it was methodically planned, and did not grow up happazardly. There the houses and public buildings were laid out in true orientation, and built of bricks and mortar; the streets and lanes were paved and bordered with drains and pavements. "Either the city" says Mr. Earnest Mackay, "must have been built on a definite scheme from the commencement of its history, which followed perhaps on a compulsory move from another site or the arrangement of the city was the result of deliberate reconstruction on town-planning lines by order of the city fathers or a higher authority".

The existence of great cities, in pre-historic India, is evident from the Vedas. The Vedic Hindus had to fight with Anu, a tribe of Dasas, who had seven cities. "Several cities belonging

to Asuras are also mentioned, namely, Patala, Saubha, Prajyotisha, Hiranyapura and Thaskshasila". It is not known whether all these mighty cities were subdued by the Vedic Hindus, but capitals of Hiranyapura and Prajyothisha appear to have been subdued, for the Puranas state that certain Asura kings who held these cities were defeated and killed by the gods of the Vedic Hindus, though these kings had such invincible powers given them by thier God Siva. Thaksha-Sila appears to have been a very mighty city against which the Vedic Aryans had to fight for long. If this Takshasila was the same as the Buddhist Thakshasila, whose ruins are near Peshawar, the chances of the Aryan invaders coming through the Khyber pass should be discounted. The Asuras appear to have been great builders of cities and forts, and their Silpis were in great demand even by the Sura or Aryan kings. The principal Asura kingdoms during the Vedic and Puranic periods were Magadha and Kamapura in the north, and Kalinga, Kerala, Chola and Pandya in the south. The capital of the Ancient Magadha was Girivrija, a fortified town. The ancient capital of the other countries are not known. Though the Dravidians had developed their navy very early, spread their colonies far and wide conquered Pegu, Arakan and many islands of the Indian Archipelago, the ports from which they set out for this enterprise are not known. "The local chronicles of Talaings claim that the Capital of upper Burma Tagaung or Devaka was founded as early as 2,600 B. C. by Klings, or the people of the Three Kalingas".

According to the Puranas, it will be seen that Royal power in the Gangetic Plain, first developed in Ayodhya, Mithila, Prathistana, and Gaya, and on the west coast at Kushastali. Of these "the Manava City of Ayodhya is the most ancient", where King Manu reigned probably earlier than the third millennium

B. C. Of these cities Ayodhya and Gaya still flourish as cities. The exact locations of Mithila and Kushatali are not known; Prathistana can easily be located as the present Jhusi on the opposite bank of the Ganges at Allahabad, though the exact site of the ancient town may be in the bed of the river by the fort. Ayodhya and Gaya have been built and rebuilt with the result that the ancient lay-out can no longer be traced. However, an elaborate description of Ayodhya is given in Ramayana as it was in the days of Rama Chandra, sixty-fifth descendant from Manu, the great Manava King. In Ramayana, it is stated that "On the banks of the (river) Sarayu is a vast, fertile and delightful country called Kosala. In this, country there is a city called Ayodhya, greatly famed in the world and built by Manu himself. This great and prospersous city was twelve yojanas in length and three in breadth, and stored with all conveniences. The streets and lanes were admirably disposed and the high roads were sprinkled wtth water... ..It was adorned with arched gate-ways and beautiful range of shops; it is fortified with numerous defences and war machines and inhabited by all sorts of skilful artists It was crowded with bards and musicians, filled with riches and shone forth with unrivalled glory; it had lofty towers stored with fire-arms and adorned with banners. It was constantly filled with female stage players; it was beautiful with gardens and groves of mango trees and enclosed with high walls. It was surrounded by impassable ditches and secured by fortifications difficult of assault by foreign kings; it was full of horses, elephants, cattle, camels and mules. It was ornamented with the palaces of exquisite workmanship, lofty as mountains, and enriched with jewels, abounding with beautiful houses consisting of several stories..... It was crowded with tributary princes, puri-

fied with sacrificial rites, and filled with merchants of foreign countries. Its aspects had an enchanting effect; and the whole city was diversified with various colours, and decorated with regular avenues of sweet scented trees. It was full of precious stones, and resplendent with stately edifices and beautiful apartments. It was filled with buildings erected close to one another, and without intermediate voids, and situated on a smooth level ground. It abounded in delicious rice and water sweet.... ..It incessantly echoed with the sounds of kettledrums, tabors, cymbals and flutes; this city truly surpassed any that was ever beheld on earth".

The Ramayana being in poetry, allowance should be made for poetical exaggeration in this description; still undoubtedly a clear idea of civic life and city lay-out, as conceived by the poet at any rate can easily be seen from this description. The oblong lay-out in which the length was four times the breadth or a definite multiple of breadth was a special feature of the Silpi lay-out. The continuance of this practice is seen in the lay-out of Dwaraka, as reconstructed by Krishna probably before the tenth Century B. C. The length of Dwaraka was one and a half times the breadth, being 12 Yojanas in length and 8 Yojana in breadth; while the length and breadth of Ayodhya was 12 Yojanas and 3 Yojanas respectively. A Yojana is given as 9 miles by Ram Raz, the author of the "Architecture of the Hindus". Even in these days of great industrial developments it is difficult to conceive a city 108 miles long. Shamasastry who translated Kautilya's Arthasastra gives $5\frac{5}{44}$ miles to a Yojana; this also appears to be too high. One Yojna was 2 Nalikas, and one Nalika must have borne the same basic relation between the Indian and the English measurements which was 3 to 4.

However, from the description of Ajodhya as given above, it is evident that it was not only that part of the city, which was " filled with buildings erected close to one another and without intermediate voids" that was included in this huge area but the suburban residences of the tributary princes, with extensive gardens and "high walls" as well.

Towns of considerable sizes appear to have existed in India in prehistoric days. The fortified parts alone of Girivrija, the old citadel of the Magadha Kingdom, had an encircling wall about 30 miles in perimeter, pierced by 32 large and 64 small gates protected by stone towers. The walls were made of rough-hewn stones, 16 feet thick. Its defences excited the admiration of Bhima, the big fighting brother of Dharmaputra, of Mahabharata fame. Without systematic excavation it cannot be determined what particular type of Silpi lay-out was used in planning this town.

Percy Brown estimates that this town is as old as 800 B. C. But certain references in the Puranas will show that it is older still. Krishna had a long feud with Jarasandha, an ancient king of this town. Here a great basement known as "Jarasandha-ki-baithak" is pointed out to the travellers. It, according to the Gazetteer of India, "is about 85 feet square at the base, and slopes inward from twenty to twenty-eight feet to a platform seventy-four feet by seventy-eight, built entirely of large unhewn stones, neatly fitted together without mortar, and contains fifteen cells, mostly on the north side, each six to seven feet in length and a half this in width". Before Jarasandha, his ancestor Brahadratha, an Emperor of the same dynasty reigned there. This line of kings, was succeeded by the Sisunga dynasty; one of the

Sisungas, probably Bimbisara, the 5th or 6th Century B. C. built another town, about a mile and a half from the gates of the old town, known in Buddhist literature as Kusagra-pura. Girivrija or Girivrija-cum—Kusagra-pura appears to have been a big town of importance; Buddha accompanied by a huge retinue, paid a visit to this town; Mahakasyapa, the principal disciple of Buddha, held there a great assembly of monks. Even after the removal of the Magadha capital from here, it remained a place of great pilgrimage both for he Buddhist and the Jains till the 12th century A. D.

Fortunately we have some details about the next capital of Magadha, recorded by foreign writers; although these details do not throw much light on the actual plan of the town, the civic side of it can be deduced from them. This new capital of the Magadha Empire was Pataliputra. It was originally a village called Patali at the junction of the two Rivers, the Ganges and the Sone. Here the king Ajathasatru originally built a strong fort, presumably to withstand the incursion of the so called Indo Aryan enemies into South Bihar. To this fort the later kings of Rajgriha gradually shifted their capital. And the move appears to have been completed by Nanda Kings. The glory of the Nanda Kings may be seen from the details given by the historians of Alexander the Great. They state that the Nanda kings maintained a cavalry of 80,000, an infantry of 200,000, four horsed chariots 8,000, and 6,000 war elephants. During the days of Chandra Gupta, Patali-putra is described as a city nine miles along the Ganges and one mile and half broad in the shape of a parallelogram. It was surrounded by a stupenduous palisade of timber at intervals with five hundred bastions with towers and sixty-four gates. In the King's portion of the town, Aelian states "besides

much else which is calculated to exeite the admiration, and with which neither Susa or Ekbatana can vie, there were other wonders besides. In the park tame peacocks were kept, and pheasants which had been domesticated; there were shady groves and pasture grounds planted with trees, and branches of the trees, which the art of the woodsman has deftly interwoven; while some trees were natives to the soil, others were brought from other parts, and with their beauty enhanced the charm of the landscape..... The main portion of the King's residence consisted of a series of hypostyle halls containing pillars of wood each of which was clasped round with vines embossed in gold and ornamented with designs of birds and foliage in gold and silver". Unfortunately no records are available to show the detaiied lay-out of the town, but there is no reason to suppose that the city was not laid out on the model of Ayodhya, Dwarka or Mohenjodaro, with parallel streets, cross roads, parks and squares.

For details of town planning in ancient India, one has to fall back on the Puranas, Agamas and Silpasastras. Though the details given in them are meagre and confused, they are sufficient to judge the art and principles of town-planning which the ancient Silpis used in the dark and forgotten days. Krishna's direction to Yadavas in replanning the town of Dwaraka, in this respect, is most informative. They are according to Devi Purana, that the "Temples were to be errected. Let there be selection of the building plots and the placing and the spacing of the building, great triangular and quadrangular places at the junction of the roads. Ascertain the orientation of the buildings. Thus ordered the Yadavas engaged for the purpose began in right earnest; selected the site; measured up the boundary lines; carried out the division of the plots, and on an auspicious day,

made offering to the presiding deities of the Vastu or site. When they were thus to commence the work, Krishna reiterated his, instructions and laid special stress upon the establishment of divine edifices. They carried out the orders, reserving special sites for trees". There directions may be considered somewhat mixed up, but when they are put in proper order, it will be seen that they are exhaustive and complete. From what is given in Silpa Sastras, the order may be regularised as follows:—

(1). Bhumi-Samgraha (Study of the site)
(2). Bhu-Pariksha (Examination of the site)
(3). Dik-Parichheda (Determination of the Cardinal points).
(4). Pada-Vinyasa (Survey of the ground).
(5). Balividhana (Checking the survey by performing sacrifice).
(6). Bhumi-Vidhana (Transfrerring on the ground the layout conceived in planning).
(7). Graha-Nirmana (Design of the Buildings.)

No doubt the consideration of the town in these different aspects is very exhaustive, and it is doubtful that we can add much to the list. Some of these items may appear superfluous to us; but actually they are not, the expert town planner will go through the whole list, though in a different way, the difference is due to advancement in science, introduction of instruments for survey and difference in the ways of making plans and doing the layout.

Bhumi-Samgraha: The term is often translated as the selections of site; it is incorrect; it should mean collection of all informations pertaining to the site, such informations that will either induce the authorities to accept or reject the site. As

such it should include geographical, topographical, historical, geological and botanical details of the site, all in relation to the needs and requirements of those for whom the town is to be constructed or reconstructed. How far the ancient Silpis succeeded in this respect is not quite clear, but persistent existence of some towns in old sites may indicate that their judgement was well founded. Though many a town that they established had disappeared, some are still in existence. Mohenjo-daro and Dwarka have disappeared but Ayodhya, Benares and Gaya still exist. Disappearances of the ancient towns may not be entirely due to defective planning; change in topography, climate and political conditions might have caused the destruction of many. It may be a change in climate that made the Indus Valley people leave Mohenjo-daro; the abandonment of old Kampilya was due to the vagrancy of the River Ganges, which followed once to the right of the town hut now to the left of the old site Musaris or Cranganore was an important sea-port on the Malabar Coast during the days of the Greek trade with India, but it is now over twenty miles inland. Dwarka disappeared due to the encroachment of the sea; while the medieval Vijaynagaram lies in ruins due to Mahomedan vandalism.

(ii) *Bhu-pariksha*: Examination and actual testing of the site: A copious water supply and the fertility of the soil were the primary consideration. The proximity of water induced the Silpis to select sites by the side of the rivers, while the question of fertility made them exhaust alluvial plains before exploring the hills and table lands. Of the sites by the river the Silpa-Sastras give preference to the site on the left bank. The reason for this is not understood. Kampilya and Prathistan were on the left banks

of the Ganges; while old Agra, Muttra and Delhi were on the right bank of the Jumna. Therefore the Silpi preference at any rate in this respect was not consistent. Geographical considerations made them establish many a town on the important trade routes and on the sea coasts and river banks. Taxila may have had its origin in defence or trade, Indra-prasta took shape as a key position from which the Doab could be ruled effectively and also protect it from the enemies of the North-west. In the selection of Benares the Silpis have shown the highest topographical understanding. Benares or Varanasi, on the left bank of the Ganges as the name indicates was between the two rivers, Varana and Asi. Here the subsoil is hard kankar, on which the erratic and erosive actions of the Ganges for milleniums have left practically no effect, though some ghats are now showing signs of decay. Ayodhya is still preserved from the erosion and high flood of the Saraju. Though the town was located on the bank of the rivers, the domestic water supply was mainly from the wells and tanks. Shallow wells had been sunk everywhere, but it appears that they had known the advantage of getting water from lower water bearing formations, for deep wells are found in brakish areas. There were water diviners among the Silpis. Though the "Irish water diviner's twig" was unknown in ancient India, the Silpis had their own methods. The most important of them were the flame method and the absorption test. Before the application of these tests, the diviner walks over the site, looks for mysterious signs, tokens, and omens; and if they are propitious then only he sets down for the test. The test by flame is done by lowering a burning wick into the pit,

the diviner watches the flame; from the behaviour of the flame in a still atmosphere he predicts the proximity of water. The absorption method is done by squeezing the juice of certain leaves into the bottom of the pit and watching the nature of its absorption. These methods of divination are still practised in the country, though the number of those who can divine correctly is getting less.

The fertility of the soil is judged by the growth of the trees, shrubs and grass on the site and studying the nature of the soil. In selecting new sites the fertility is tested by actual cultivation. Such cultivation used to be commenced with great pomp and show, sometimes the king himself took the lead with a golden plough, drawn by highly caparisoned oxen. Books like Manushyalaya Chandrika give simple methods. A pit of about 18″ square and 18″ deep, should be made. It is then filled with water and the quality of the ground is judged by the nature of absorption. Another test is done by filling up the pit with the earth taken out; if there is surplus earth, the ground is good. A third test is to fill the pit partially with water, and on the still surface of the water to throw petals of certain flowers; and if the petals move about in a clock-wise direction, the ground is supposed to be good. Some of these serve to test the stability of the ground in addition to its fertility. The ground they classified into four groups, and gave them four well-known names. The land with the whitish colour, with the smell of ghee, sweet to taste and with the growth of "Kusa" grass, they called Brahmana. The land with the reddish colour, with the smell of blood, with sour taste and with the growth

of "Darbha" grass they called Kshatrya; the land with yellowish colour, with a smell of cooked rice, bitter in taste and with the growth of "Karuka" grass they called Vaisya; and the land with blackish colour with the smell of spirit, hot in taste and with the growth of "Ama" grass, they called Sudra. The classification under these four names has created a great deal of misconeption among the ignorant people who consider that the land under these classifications is that has been ordained for the respective castes. If it were so, no Brahmin should live in Central Provinces, where the ground is black and most suited for cotton growing.

Dikparichheda, Padavinyasa and Balividhana: All these can be considered as one process of making the plan of the lay-out in the Silpis way. On the site, the cardinal points were fixed by methods described in Chapter II. They had no prismatic compass, and so they had to undergo a laborious process of Dik-parichheda, or determination of the Dik or country (hence directions). By Pada-Vinyasa they made the plan according to their squaring system as fully explained in Chapter III. By Bali-Vidhana or sacrifice on the squares they tested their memory as to the location of the respective squares and got themselves ready for constructive operations. All these appear to have been first done on a small scale at the site probably on the central plot called Brahma (creative) for reference during the course of the lay-out and construction; hence arose the restriction to keep the central plot free of any edifice.

Bhumi-Vidhana: This was the actual lay-out on the ground of the roads, lanes, open spaces and buildings, wells and all other features of the lay-out and future expansions.

Grahanirmana: Garha, in the restricted sense means a house, but in its wide sense, it comprises all structures and buildings. Nirmana means to design and build. The Silpis have taken great pains in planning and designing various classes and types of buildings, and the Silpa Sastras are full of these details. A classification of these designs may give valuable information at any rate to see what were the troubles and difficulties they had to encounter: some of which may be of some assistance to us to meet our difficulties. They only had bricks, stones and wood; they had no steel joists. Wood as a permanent material for constructuion was not very satisfactory on account of the great temperature variations in the country, except in certain parts. Bricks and stones were the alternatives. For massive work, stone was excellent but it was very expensive to be shaped in required sizes and forms, and it was not possible to get it in required lengths. For long beams, stone could not be found though they took full advantage of the safe lengths that were available. Hence it will be seen many a design had to be made according to the nature and length of the available stones. Even the design of the buildings made during the Mogul period is influenced by the nature and quality of stones. Bricks they made in different dimensions even from the days of Mohenjo-daro; at Bhita, Kausambi and numerous other places, large size bricks covering the entire thickness of the wall, were often made, also special rediated bricks for wells and drains, and geometrically shaped bricks for the altars.

To find suitable and satisfactory roofing material was one of their great difficulties. In fact this problem is still

with us, it has not yet been fully solved in this country. The western designers are still experimenting. Once, Jack Arch roofing was considered a remedy for all ills. But soon it was found ugly and unsatisfactory. Reinforced brick roofs were tried; though it removed the ugliness to some extent, water proofing still remained unsolved. The reinforced concrete is still on trial. It developes cracks, due to great variation in temperature. The water proofing material was then laid on the reinforced concrete, and lime concrete on the top. This is also not quite satisfactory. Thus roofing problem still remains unsolved. The ancient Silpis used wood and tiles for the roof; both being perishable articles, renewals and replacements were constant problems to be faced. They tried stone slabs, but the stone slabs necessitated innumerable pillars, as the stone beams were not long, so they had to make the design to suit the material. Waterproofing they effected by mass concrete on the roof, which made its elevation ugly. To remedy the ugliness they faced the concrete with stone, which should easily be considered as the genesis of the conical temple roofs. Then to improve on the plain surface, moulding and carving, both plain and ornamental were adopted. But this was an expensive affair, and could not be adopted except in special cases; and the roofs of ordinary houses had to be left alone without a remedy. People talk about the absence of any building of pre-Buddhist period; an explanation for it can easily be found in the roofing problem. Buildings roofed with wood and tiles disappeared, first the roofs and then the walls. However, if one goes into the details of 'Silpi design and construction, it will be seen that they did a tremendous lot in parity with the materials available.

No complete or comprehensive treatise on the Silpi town-planning has been found. But from the Silpa-Sastra, Agamas and Puranas, a great deal of information can be collected. The greatest authorities on Town-planning were Sukra and Maya. Both of them were great sages; so we are enjoined to take everything that they are supposed to have said as gospel truth. We have no sufficient means to judge their wisdom what they are supposed to have said may not have been said by them at all.

In Manasara-Silpa-Sastra the following typical plannings are mentioned:—

(1) Dandaka
(2) Sarvatobhadra
(3) Nandyavarta
(4) Padmaka
(5) Swastika
(6) Prastara
(7) Karmuka
(8) Chathurmukha

In Maya-Mata the following four more types are given:—

(9) Padma
(10) Prakarnika
(11) Paraga
(12) Sri-Prathishtita

In Kamik-agama all these and additional four types are given:—

(13) Sampatkara
(14) Kumbhaka
(15) Srivatsa
(16) Vaidika

From a careful study of what is given in Manasara and elsewhere a good many details of the Silpi planning can be ascertained.

(1). Dandaka: this, as it is indicated by the name, is primarily a long layout, like a " danda" or long pole. The name must have originated from its first application at the long high ways. Mayamatha describes the layout thus:—" Its streets are straight, and cross each other at right angles at the centre running east to west and south to north, the layout has four sides and four gates or openings. Even if it has only one street, yet it is called " Dandaka ". This comprehensive definition is narrowed down in Manasara, when the author states that this should have " three rather five carriage roads, and there may or may not be a street running from end to end; one similar street may or may not run straight through the middle". Presumably Manasara was thinking about smaller settlements. However the main feature of this lay out may be summed up as follows:—The main streets run through the centre of the town; they should have on either side buildings and foot paths. Parallel to the main streets any number of similar streets may be provided, as are required. Main streets should have subsidiary streets or lanes between them, it is preferable to have at least one paved foot path for each street; the main parallel streets must have at least three main cross roads as good as the main streets, one at the centre and others nearer to the extremeties of the town. Another feature of the lay out is that the length of the town should be twice its breadth. Out of the eight lay outs mentioned in Manasara, all except two are specified to have this proportion, the two exceptions are Padmaka and Swastika lay outs whose lengths should be equal to breadths. Yet no mention is made anywhere how a plan based on the squares should be adapted to a double square, where the lengths are twice

the breadths. But it should be admitted that there is no difficulty in considering plots with the lengths twice the breadth, if the principles of Silpi Survey are grasped properly. Making the length of a town equal to twice the breadth is an old practice, the length of Dwarka was twice its breadth. The length of Ayodhya as four times the breadth, may indicate additions to the original design. The architects in ancient days appear to have had a predilection for such proportions; King Solomon's temple had its length twice the breadth like the Hindu Temple at Guruvayoor. Mosques in India are based on three squares, or the length is three times the breadth, while the Taj-Mahal is a single square like most of the Hindu Temples. The Hindu Temples circular in plan commenced with the extensive use of bricks and stone.

In Silpi lay-outs the streets are to run due north-south and east-west. Some are of the opinion that such orientation was necessitated by the religious rites of the Vedic Hindus; but they do not quote what particular religious rite has necessitated this orientation. Even when the Hindus pray to the Sun, they do not observe true east and west, but simply follow the course of the Sun. However, streets running east and west cannot make the house turn to the east. It appears that the Silpis were great on correct orientation long before the Vedic times. At Mohinjo-daro and Harappa the streets run "almost true north and south and east and west." Earnest Mackay says that "At Mohenjo-daro the prevalent winds are from the north and south, and the main streets may have been oriented in accordance with this fact". However correct orientation has been one of the main features of the Silpi lay-out. They laid out not only streets with proper orientation, but all the houses and buildings also with great accuracy. Every house built by the Silpi, even today is strictly orientated, just

as every building in Mohenjo-daro and Harappa was "fairly correctly oriented with their sides towards the cardinal points as was the case with the buildings of ancient Egypt." The ancient Egyptians and the Hindus follow the same orientation but the Chaldeans differ; for, their sacred buildings face the corner cardinal points.

Diagram (17) shows a Dandaka lay out. Here the length is twice the breadth, and 81 plots into which the whole area is divided have also their lengths twice the breadth. The names of the presiding deity of the plots are also shown. Why certain gods should get greater number of plots is not known; an important god like Yama is getting only one sixth of the area allotted to Vivasvan. It might probably be for the purpose of treating the large plots in particular fashion, or on a unitary basis. Brahma gets 9 plots, and there is a strict injunction that the Brahma plot should not be built upon. Original intention certainly has been to leave the Brahma plot as an open space; but later writers and interpreters began to misconstrue that Brahma plot was for the temple of Brahma, a god for whom the Hindus seldom construct temples. Manasara does not specify any temple in the Brahma plot; according to Manasara, the temples are disposed of thus :—" A temple of Vishnu should be built in the outskirts towards the west or inside on the Varuna or the Mitra part; and..........the temple of Siva should be made outside, towards the north-east, or inside in the Prajanya and the Uditha parts." Here a tendency is noticed to locate the temples away from the centre of the town. The temples were civic centres undoubtedly at one time, when religion was complimentary to the civic activities of the people. The temples away from the centre of the village, and at the outskirts, are even now an important feature of the country side. When two or more temples are constructed

they are often put at further ends of the village or town. If this was the civic ideal in ancient days, the so-called temple towns of India become a misnomer as in temple-towns, the towns are supposed to have sprung up round the temple. Probably in a state of chaos, under foreign invasion and such like, people might have collected round the temples with strong and high protective walls for refuge.

In all lay outs a great deal of stress is given about the erection of the temples, though this does not appear to have been the practice always. For Manasara says, "In fact in ancient town or village temple of god, was not invariably built; therefore in accordance with this criterion, the disposition of the houses or buildings should be carried out". Perhaps he might have had then in mind the instances of towns like Mohenjo-daro where excavations have not revealed the existence of any temple or place of public worship. In fact the oldest Hindu tradition appears to have been to worship without temple or image, a practice which has not completely disappeared. In many a Tarawad or ancient house of the Nairs on the Malabar Coast certain rooms in the main buildings are set apart for worship, these rooms contain no image of any kind, and they are constructed just as other rooms in the house. However in course of time the construction of temples became a main feature of the Hindu planning. Even Krishana appears to have given great stress in establishing temples in his new city of Dwaraka. This may be due to a change in the civic conception, In the villages it will be seen that the civic centres are the village wells or the banyan tree at the cross roads, where people collect to meet the neighbours and gossip. The plot round these trees became the places for sacrifice, with a presi-

ding deity first under the tree. Temples were not made for the presiding deity for a long time, as it will be seen that primitive goddesses like Durga (or Vanadurga) and gods like Sasta and Ganapathi are even now in most cases without any roof over them. The covered platform, in front of the temple, for the elders to sit, seems to have developed long before the evolution of the temple. The so called tree-worship in India appears to have its origin in worshipping under a shady tree. The tree was gradually substituted by images; first images under the trees appear to have been of the Nagas and Yakshis or jungle spirits, and then gradually they were replaced by high gods with higher spiritual attainment. No doubt the temples became the dominant civic centres, some of their old glory are still with them, though in a debased form. The temple tank used to be the bathing place for all; in those days young and old, rich and poor used to take a pride in keeping the temple tank and premises neat and clean. Now these have become the property of a class or individual who will spare all expense on them if he can help it. The tanks that are still the common property of the public are well looked after. For cleaning the tank of the golden temple at Amritsar, even the Mahara ja of Patiala has to lend a helping hand. The use of the common kitchen and dining rooms (oottu-puras) became long a caste prerogative. Mandapam, which used to be the meeting place of the elders had become thoroughly untenanted, except for occasional use by some one who desires to show his caste prerogative or exclusivenss. The sacrificial altars, the "Bali Stone", in front of the temple became a mere appendage in construction, except for some occassional mysterious rites by the "Poojari" or the priests of the temple. Even the much maligned Deva-

dasi institution, which had its origin in keeping public entertainers at the civic centres, like the municipal bands in England, has become an unlicensed establishement for prostitution. All these took place when public institutions became private property. The Brahmins are not entirely to blame for this, as there are non-brahmin userpers also among the temple proprietors. With the downfall of the temples the civic life in the towns and villages have deteriorated, the degree of civic deterioration is proportional to the degree of temple deterioration.

From Dandaka lay out, just as in any other lay out, it will be seen that the gods for whom the temples were to be erected was not the same gods who presided over the plots. The gods of the plot are vedic or pre-vedic gods, hence it is obvious the Survey system existed long before the advent of the Puranic gods. The Dandaka lay out which appears to have originated at the cross roads of a main thoroughfare, has further been enlarged and developed into Saravato-bhadra, Prastara and Chuturmuka.

(2). *Sarvatobhadra*: The description of this lay out given in the texts is not clear. It was not clear to Ram Raz, hundred years ago when he wrote the "Architecture of the Hindus" for the Royal Asiatic Society of London. No new facts have come to light to add to our knowledge. Manasara states:- The lay out is a square one. The area may be divided into Standila (49 squares) or Manduka (64 squares). It can have one to five carriage roads, or main streets, together with a surrounding street. The latter apparently means streets along the perephery. In Paisacha Vithi, there should be a street running through all the plots, and this street should have foot paths on both the sides. At the four corners there should be a monastery, temple, or guest

house. Drinking houses should be provided in the south-east; other public houses in quarters as are required. At the four directions, there should be main gates. The houses of all kinds of working men should be on the high way, and the Sudras should be housed on the south side. Between the east and the south-east should be milkmen, and beyond this (presumably outside the town) cow sheds and the dairy. Between south and west the weavers and their looms; beyond these, should be the quarters for the tailors and also for shoe-makers. Between the west and north-west should be the place for blacksmiths, and also for fishmongers and butchers. Between north and north-west should be the place for Srikaras, a literate community, whose skill was at the service of all. In the same area was the residence of the Vaidyas, or the men who practised medicine. Beyond these, the quarters for those who extract oil from seeds and nuts, and also for those who deal in the bark of trees (probably tanners). In the outside of the town, at some distance towards the north, the quarters for the dead body burners; in the same locality the temples of Chamunda and Vaishnavi, apparently the goddessess which the undertakers worshipped. In suitable centres, the temples for other gods. In south, west or south-west, tanks for water supply, both for drinking and bathing. From such details as above the following further characteristics of the lay out may be deduced :—

(1). By the mention of streets in the Paisacha Vithi, it is apparent that a new division of the area into Vithis has been brought into use. It has already been stated in Chapter III that according to Vithi division, the outer round is called Paisacha round, next one to it is called Manusha, the next inner round is called Daivika, and the inner plot is called Brahma. It is in such a Paisacha Vithi that there should be a street running through

all the plots, and this street or streets should have a carriage road with pavement on both sides, thereby showing that it was an important street.

(ii). By allotting different plots for different trades and professions a kind of zone system has been introduced.

(iii). By concentrating trades and professions, in the Paisacha Vithi, it has become apparent that intensive planning was to be in this area; other Vithis, are as they approach towards the centre, are to become less and less populated, until it reaches the centre, where there should be no building at all. This is a practice diametrically opposite to the present system where the centre is intensely built and the intensity reduces further and further away from the centre.

In Dandaka lay out it is apparent that trade and professions are concentrated towards the centre, while the residential quarters receded to the perephery of the town. Concentration of trade and business at the perephery of the town has a great advantage; when they increase, outlying areas can be tacked on towns and developed without inconveniencing the inhabitants and remodelling the entire town at tremendous expense.

(iv). The proper name of the Vithis has no significance whatsoever, for Brahma is not for Brahma, Daivika is not for Brahmins, and Paisacha is not for the Pisach or the devils. The reiteration of this has become essential, as there are many among the Indians and outsiders, who still hold wrong views in this respect.

(v). As there is one main street specified through the centre of the Paisacha round, it can be assumed without erring too much, that the theme in planning was to have similar streets through

other Vithis as well. If so there will be four sets of streets going all round in a square, including the one through the perephery, and one street going east to west and another one going north to south, vindicating the number six given in Manasara. But the exactness in the number of the streets was never to be enforced, it was left to the Silpi to decide according to the requirement, a fact which is emphasised time and again by Manasara. One thing to which they appear to have given a great deal of stress was the provision of less important roads or lanes between two important streets, preferably with one pavement on one side. Not enough can be said about the utility of this. Then again there was no hard and fast rule that there should be only one set of roads through a Vithi all round, elsewhere it is stated that Paisacha Vithi can have 2, 3, 4, 5, 6, or 7 roads, presumably according to the exent of the town, and the consequent increased width of the Vithis.

Diagram (18) shows the main features of the Sarvatobhadra lay out. Here each Vithi or round is divided into two by the main streets running through the centres. The outer Paisacha road is set apart for workshops, looms etc., while the inner Paisacha is for shops and business. The outer Manusha round may be for better shops and residences combined, or residences only; while the inner one is for residences only. The outer Daivika round is for better class residence, while the inner one for public buildings, temples, palaces, etc. The corner plots in every round are best suited for civic centres, such as temples, drinking and eating houses, music and dancing halls, residence of preceptors, etc. It appears that there is no objection in having a civic centre or a public building in the Brahma plot, though it is considered best to leave it as open ground at the junction of the four

arterial highways radiating towards the four cardinal points. Unfortunately Manasara does not give the zone arrangement in its entirety, what is given appears to be the most important allocations only, or the transcribers might have left out the allotment of other zones.

Nandyavarta: Manasara gives a great deal of details about this lay out but they are singularly difficient in presenting its chief characteristics. The plan of one town differs from the other mainly in the lay out of the roads and streets. The names given to different lay outs by the Silpis had meanings only in relation to the arrangement of main streets. The writers of the Silpa-Sastra appear to have overlooked this fundamental fact and have left us to imagine those principles; or to build them up from fragmentary references and involved explanations. These writers have undoubtedly done incalculable service to to posterity, but they often have given importance to such details, which at the best could have only a local value at the expense of the fundamentals, probably due to their ignorance or lack of information at the time of writing them down. The name Nandyavarta given to this lay out is a typical example of the kind. Nandyavarta, or Nanthyarvatam is a thick white flower that grows on a bush. The main peculiarity of the flower is the overlapping of the petals. This characteristic of the petal is adopted in the lay out of the streets in Nandyavarta. In Manasara text nothing much of this is mentioned but a passing reference is made twice to the root of the streets. The root of the streets should indicate that certain streets are shoot off from others, and when it is applied to streets that are perpendicular to each other the meaning becomes self evident.

Manasara Directions are as follows :—

The length of the town should be twice the breadth, in that case the division of the ground to be adopted is Paramasayika or 81 divisions. But the length can also be equal to the breadth then one should adopt 64 divisions of Chandita or Manduka. There shuold be large streets (rathyas) both lengthwise and breadthwise. And one to seven of them should be finished with two foot-paths beginning from the root. Paisacha round is to receive special attention. Eastern carriage roads should run north to south, southern should run from east to west, western from south to north, and the nothern from west to east. "One foot path from the root to the top should be attached either to the two internal streets running from south to north or to the two internal streets running from east to west; and the remaining two at the two sides are stated to have two foot paths each".

In Paisacha round there should be two, three, four, five, six or seven streets. The houses of the Vaisyas (or main shops) should be situated on the first street in the south. In the Varuna and Mitra parts should be the palace of the Emperor and the residences of the Royalty. The Jayanta and Rudranjaya plots are for the princes. In some suitable part in the south-west should be Srikaras or those who follow writing as a profession. In the Asura or Sosha plots should be Samanthas or the Ministers, and somewhere there also should be located the residences of the nobles. The houses of the priest, should be located in Sugriva or Puspadanta plot. The Danurvarika and part of the Sugriva plots should be ṣet apart for the Rakshakara, the king's bodyguards. In the Gandarva, Roga, or Sosha part should be the place for the band, musicians and dancers. In the Vayu or

Naga should be the houses of the Silpis. In the Mukhya should be the place for Netra-rathnakaras, those who deal in gems. In the north should be the place for armourers. In the Aditi or Udithi should be the houses of the Vaidyas (or members of the medical profession). In the north east should be the place for the police and watchmen (and their head-quarters). In the Mahendra or Satyaka should be the place for Karnikaras, probably palanquin bearers. In the Brisha or Anthariksha plot should be reception rooms and guest houses, and so on. As is in the case of Sarvatho-bhadra, the Manasara Silpa Sastra does not give full details of the zone arrangement, however the main idea can more or less be grasped. Here again it will be seen that the shops and business centres are in the outer or Paischa Vithi, and the residential quarters are towards the centre of the town. The centre of the town should be kept open, but at the discretion of the Silpi; a pavillion or shrine may be constructed there probably to form a feature of the lay out. The temples or shrines as usual can be constructed anywhere according to the requirements, though one who reads the Manasara will get an impression that all the temples mentioned therein should be built in the respective places. However, the location of certain temples gives us some valuable information. The place specified for the temple of Durga is the Puspadanta plot, which is next to the Varuna plot, where the palaces are. This would show that the kings and the members of the Royal household were Durga worshippers; it is also in this plot, the houses of the priests were. Who were these priests? Certainly they were not the high class Brahman who claimed the exclusive right of occupying the Daivika round. Further the so-called high class Brahmans generally do not do "Puja" to the Goddess Durga, it is left even to-day to

lower class Brahmans. The high class Brahmans never appear to have been priests, in the sense they ministered to the needs of the public whether at the death, birth, or marriage ceremonies or at congregational functions (as is done by Christian priests). These functions in the Hindu Community are performed by inferior Brahmins, or priests of a lower grade. It is remarkable to notice that even now the "Pooja" in certain very ancient and most important temples like Puri are done by non-Brahmins. However might it be, the location of the Durga temple adjacent to the palace, gives some idea about the period at which this lay out had been originally made. It was long before Vishnu or Brahma periods, or the periods at which these Gods rose high in the Hindu horizon.

The main principles of the Nandya-Vartha lay out are shown in diagram (19) where the length of the town is twice the breadth. It may seem that if the length is made twice the breadth, it would give larger plots at either ends of the lay out, where princes and merchant princes vie with each other to build magnificient buildings. Here the same as in the case of Sarvatobhadra the outer rounds of the Paischa Vithi are for business and trade, the next two inner rounds of Manusha Vithis are for houses; the outer round of Daivika Vithis is for the residences of the better or richer class people, while the inner round of this Vithi is set apart for public buildings and such like. The Nandyvarta lay outs is an improvement on the Sarvatobhadra for the Nandyvarta lay out do away with large numbers of squares at the corners. Hence it must be for this purpose the overlapping idea of Nandyvarta has been introduced.

Padmaka: According to Manasara, in this lay out the length and breadth of the ground is taken as equal and it should be divided

into 64 or 49 plots. "The residential buildings should be built in the six plots each divided by an oblique line." "There should be four, five, six, seven or eight streets." "All carriage roads in the exterior as well as in the surrounding ones should be furnished with foot paths." "Across the middle there should not be any street, the gates should be made towards the four directions. The rest should be made as stated before."

The chief characteristics of the lay out can be determined from its name Padmaka, which means like a lotus, and from the statement that the residential buildings should be built in the six plots each divided by an oblique line, the oblique lines are evidently the diagonals drawn for the square ground, and when a circle is drawn with a radius equal to half the length of the ground, this will cut the diagonals, giving six plots which are cut by the diagonals into half plots. It is on either side of these diagonal streets that the most important residential quarters are to be built. The four streets that radiate to the east, west, south and north are apparently to contain the important public buildings presumably to the extent of the Paischa Vithi. These two sets of roads should not cross each other at the middle, or Brahma plot, which should be circular in this case, so also the roads in three rounds, Paischa, Manusha and Davika. One circular street runs through the perephery, one each through the centres of the Paischa, Manusha and Davika Vithis. Thus eight important streets are obtained. There should be secondary streets as usual between the main circular streets.

Diagram (20) shows the lay out of the town of the Padmaka type, one half of it just the same as described above, while the other half is a modification of the same, in which the connecting streets through the perephery and the three rounds are made

traight, instead of segmental, thereby giving an octagonal shape to the entire lay out.

Swastika : Manasara states that the length and breadth of this town should be equal, and the ground should be divided into 81 divisions. Through the Paischa round as well as through the periphery carriage roads should be laid out. It is apparent that the streets through the Paischa round are to be laid in Nandyavarta fashion. The streets through the next two rounds should be laid in Swastika fashion. Swastika is one of the two mystic crosses of the Hindus, the other one being Sauwastika. Sauwastika is attributed to Vishnu, the principle that ensures the smooth running of the Universe. Swastika is attributed to Sakti, the Goddess of power. These crosses consist of two main parts, one is the stem and the other is the arm. The stem portion is the ordinary cross with four equal arms, perpendicular to each other, and we have seen how the Silpis used this cross with full advantage in all the lay outs previously described. From the stem of the cross four arms of equal dimensions project out at right angles to the four arms of the main cross. These additional arms are fixed in clock-wise fashion, in the case of Swastika cross, and a counter clock-wise fashion in the case of Sauwastika cross. The directions to effect the Swastika cross in the lay out is given by Manasara thus :—There should be a street running straight from east to west in the middle and another running from south to north crossing the former in the centre. The other streets running towards the east extend from north to north-east; those running towards the south extend from east to south-east, those running towards the west extend from south to south-west; and those running towards the north extend from west to north-west. This completes

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the Swastika portion of the lay out. In this the projecting arms of the Swastika in all the rounds are equal, but the length of the arms of the main cross varies, according to the respective distance of the projecting arms from the centre of the cross. If the streets are laid out only so far, there will be large blocks in the four quarters without any street. To avoid this, the Swastika arms, it appears to me, should be projected back to meet the arms behind them perpendicularly.

The diagram (21) shows the main features of the Swastika lay out. It is evidently another solution to avoid numerous square blocks at the four corners, even better than the device used in the Nandyvarta lay out. In this lay out it should be noticed that four distinct zones are well marked.

Prastara: Manasara states that this town may be square or rectangular. The division to be adopted is Paramasayika (81), Chandita (64) Standila (49), or any other divisions, as desired. A large street with two foot paths should be made in Paischa round. This has become a common practice in practically all the lay outs. The instructions about the next sets of main roads are somewhat involved. "One street being constructed in Pitha block, there should not be any other street across the centre; but there should be two streets each way in all directions as aforesaid." In Mahapitha block there should be three streets each way in all directions. Then a road should be constructed round the Paischa round: extending from the interior side of this street there should be 3, 5, or 7 streets running towards the east and north."

This statement will remain an enigma, until it is realised what Pitha and Mahapitha blocks are. The Pitha is the division of entire ground into nine square blocks; and Mahapitha

means the division of the ground into sixteen square blocks. These two kinds of divisions are to be superimposed on the ground which has already been divided into 81 for instance, and again divided into four Vithis. When the ground is divided into Pitha or nine blocks, it gives four lines east to west and four lines south to north, and if streets nre made along these lines they give two internal roads east to west and two internal roads south to north. We are to understand this from the criptic statement that "one street being constructed in Pitha block" and "but there should be two streets each way." Then it becomes clear the meaning of the statement that "there should not be any other street across the centre" or when the ground is divided into nine similar plots there will be no line and no street across the centre. But this injunction given in the text applies only when the ground is considered for this division, for if the ground is to be divided again into Mahapitha, or sixteen divisions, certainly there should be streets across the centre. This is obvious from the next sentence of the instructions, namely "In Mahapitha block there should be three streets each way in all directions." "When the ground is divided into 16 squares or blocks and the roads are laid along the boundaries of these blocks, there will obviously be three streets east to west and three streets south to north. This is further made clear in the text by the statement that "if nine plots of the Pitha are connected there should be 16 crossings, and if the 16 plots of the Mahapitha are connected, it should be marked by 20 crossings. From these interpretations it is obvious that no doubt can further be entertained about the lay out of the main streets in Prastara. The minor streets or the streets with only one pavement can be made as desired.

The main feature of the Prastara lay out is shown in Diagram (22). The division adopted here is 81. It is obvious that there is no attempt here to avoid numerous square blocks, and it makes the width of the plots for important buildings, around the open space in the centre greater, and some squares bigger than the others.

Karamuka: From what is given in Manasara, it is difficult to form any definite details about this lay out. It is stated that this is a lay out suited for a town on the river bank or sea; and the outside part of a pair of the roads should be like a Karamuka. Karamuka is a bow, and based on that meaning the town is laid out by some writers in the shape of a bow, with modifications of their own. Some consider that the string of the bow is parallel to the river or the sea, while others show the river or the sea, as parallel to the body of the bow. Consequent on these ideas, they show radiating roads from the centre of the string to the bow. Certainly there is no authority for such radiating roads. Further if this lay out is to be in the shape of a bow with radiating roads from the centre of that which represents the string, it cannot be considered as a separate lay out, as such a lay out would form half of a Padmaka lay out, in principle as well as in shape.

It appears to me therefore, that Karamuka may not have been the original name of this lay out. It might have been Karamuka, which means the face of the bank or shore. Kara and Muka are south Indian words, the former denotes the bank of a river or the shore of the sea, and the latter means the face. If so, whatever details given by Manasara becomes full of significance; namely :—

(i). Karamuka should be adopted on the bank of a river or sea. And consequently that one side of the town

should be in conformity with the river bank or the sea coast.

(ii). Its length should be equal the breadth or the length may be greater.

(iii). There should be a junction at the head of the streets.

(iv). "In accordance with the suitability of the quarter the wise Silpi (architect) should make a street connecting wes and north, another between south and east, one between the north and east, and one between south and north." Here the wisdom of the Silpi is invoked, or it is left to the discretion of the town planner.

(v). "Outside part of each pair of these streets should look like Karamuka (a bow)". This means that if the river is for example on the south side, west-south street and east-south street should confirm to the contour of the river bank.

In the Diagram (23) WN is shown as north-west street, SE as south-east street NE as north-east street, and SW as south-west street Here the outside part of the pair SW and SE should look like Karamuka. This would mean that the point S may be in any position between S and O (the junction of EW and NS) along the line OS, such as S_1 S_2 etc.

(vi). Having got the four corners N, E, W and S thus "the wise Silpi should separately mark the plots in the four quarters", and "the Silpi deeply learned in the science should make them proportionate to the size of the town" or ground. Hence this is also left to the discretion of the town-planner.

(vii). The number and the position of the internal streets are also left to his discretion.

Diagram (23) shows a lay out of Karamuka made according to these directions coupled with the discretion of the writer. The ground is divided into 64 squares the point S is moved north so

as to make the streets WS and ES look like a Karamuka, or bow and to be more or less parallel to the contour of the river bank. Hence this lay out can also be designated as Karamuka, which becomes an additional feature. The ground is divided into Vithis, diagonally and main streets are drawn through the centre of the Vithis and through outside the Paischa Vithi. Intermediate streets are drawn through the boundary of the Vithis, and two cross roads are added to facilitate the approach to the open space on the river bank. This lay out is admirable for an open town; but for a fortified town so many openings to river banks is a potential source of attack by the enemy, and cannot be recommended.

Chaturmukha : This town can be a square or rectangle in shape. A large street should be made around it and this street be furnished with two footpaths. From the four plot block in the centre, should extend the streets towards the four cardinal points. There should be four gates or openings at the head of these streets. Each side should be provided with one large gate and smaller gates should be at each corner. Four smaller streets connecting these gates should be constructed. This is practically all the description given by Manasara for the lay out of this town. However from this the following further details can be deduced. In the four plots in the centre are evidently Brahma plots, it is evident that sixty four divisions of the ground are contemplated. Four gates or entrances in the corner and four small roads from them naturally indicate that these roads are to be laid diagonally towards the four corners of the town from the four corners of the Brahma plot. If so the peculiar nature of this lay out becomes apparent. In diagram (24) these diagonal roads are shown, and the rest

of the details are those that one has become acquainted within the previous lay outs. By the provision of these diagonal roads all the awkward squares and the blocks at the four corners have been avoided, probably it was for this purpose that this lay out was introduced. By showing in the text the four castes at four different quarters, a regional and zone systems have also been introduced in which the four regions are independent of each other.

Padma: Some writers are of the opinion that this lay out is the same as Padmaka. Padmaka, as has already been pointed out is a circular lay out. But Padma can be a square or oblong. According to Mayamatha, the number of easterly streets may be seven, and northerly streets three to five, though the number of easterly streets may be increased to 7 and northerly streets to twenty. This is evidently a chess-board pattern lay out. The name must have originated from the act of laying out squares for 'pooja' purpose, which is even now referred to as laying the "Padma".

For the details of all these lay outs we are mainly indebted to Manasara and to Dr. P. K. Acharya for the masterful translation of the same into English f om an obscure text We know very little about the other lay outs mentioned above. However from the meagre information available it is seen that Prakarnika is in the shape of a fan; Paraga has six to twenty three northerly streets and six easterly streets, Sriprathis ha has 8 principle high ways from east to west and 36 main streets from north to south. Sampathkara has five streets east to west, crossed by 20 traverse streets. Kumbha is in the shape of a pot, and its perephery can be curviliniar or polygonal, and the inner streets may run parallel to the perephery. In both Srivastsa and Vaidika there is no limit as to the number of streets.

Silpi principles of town-planning is seen adopted in many places outside India. A practical example of Kumbhaka lay out is seen in the restored plan of Salinus which was founded by the Dorians in 628 B. C. Here the outer road is in the shape of a pot, the inner roads are made horizontal and vertical to the axis of the pot. The plan of the ancient Alexandria founded in 323 B. C. confirms to the main features of the Prastara lay out. So is Penn's plan of Philadelphia. The plan of Mongpazier is decidedly a Dandaka lay out. The centre of Karlsruhe is laid out in Padmaka fashion, while the eastern portion of it s in Chathurmukha. For the details of these lay outs, the reader is directed to see "Town-planning" by H. INIGO TRIGGS. These are not the only examples. How these ancient Silpi lay outs filtered through the ages to the western countries is not known ; probably the western town-planning may have an independent origin.

The ancient town planning of the Hindus, is often designated as Indo-Aryan village planning, both by the Eastern and Western writers. It appears that it is neither Indo-Aryan, nor village planning. An Indian, author of "Town-planning in Ancient India" for instance, says that Paraga lay out is that of a small village. Certainly a lay out with 23 main roads and 6 cross roads cannot be of a small village. Even many of our big towns of to-day cannot boast of such large numbers of roads. The error in designating them as village lay outs appears to have arisen from two sources:—(1). From a literal translation of the Grama into village. Grama certainly can mean a village, but it had meant larger areas than villages as well. For certain, it meant larger areas in Kerala country. Once-upon-a time Kerala country was divided into 64 Gramas. These were not small villages but large tracts of land into which the

whole of Malabar Coast and probably some tracts beyond Malabar were sub-divided such as Kaviyoor Gram, Chengunnoor Gramam, etc.; in such places even now there is nothing which has the semblance of a village, as is usually seen in other parts of India. Different meanings, to the same words had been a great characteristics of the Sanskrit language. To quote an example the word Hari means the following:—Yama (god of death), Anala (god of fire), Indra (god of the angles,) Chandra (the moon), Arka (the sun), Vishnu (one of the Trinities), Simha (the lion), Amsu (the rays), Vaji (horse), Suka (parrot), Ahi (serpent), Bhejaka (frog), Kapi (monkey), and Kapil (blue-black). Where-ever the word Hari is used appropriate meaning is to be given accoring to the context. Grama at one time must have meant town as well. Or (2) it might be due to inaccurate transcription or translation. A typical instance of it may be taken from the Manasara. In Manasara the smallest dimensions for a Dandaka village are given as 25 rods by 50 rods. Dr. P. K. Acharya states that a rod is equivalent to 27 Angulas. While one Angula is three-quarters of an English Inch. Thus this Dandaka village is about 17 feet wide and 34 feet long. And this village according to Manasara should contain a minimum of 12 Brahmin houses. Even considering it as temporary war emergency accommodation, it is not sufficient to accommodate 12 to sleep. Probably some of the dimensions given in Manasara, may refer to the diagrams that they might have laid out on the ground for the purpose of "Padavinyasa" in some selected plot, probably in Brahma plot, as a model of the lay out, and for the purpose of reference during the course of construction.

Now town-planning in India is a lost art. Vijayanagar, the capital of the last Hindu Empire appears to be the last big

city laid out by the Hindu Silpis. Probably some Rajput princes in their isolated states might have encouraged the art. The city of Jaipur, is undoubtedly laid out according to Hindu Tradition. It is a rectangular lay out, containing about nine rectangles and squares all separated by arterial roads. It appears that the planner had the Prastara lay out in mind, and he took the topography into full consideration. It was not incumbent on the Silpi to follow right through any particular lay out; he was to use his discretion, and several types could be combined with advantage.

To-day few towns of India show any systematic planning. The majority of them present a very pitiable sight, with badly laid out streets, irregular lanes, crowded mohallas, stinking drains, delapidated huts and neglected mansions. Wherever one looks there is a sense of haste, neglect and insecurity. This may be a legacy from the past. In the immediate past there was no security of tenure, there was no security of life and property, every thing used to come and vanish as it were by the touch of the magic wand. A slave of to-day could be an Emperor tomorrow; an Emperor of yesterday might be a slave today. A man could rise to fame and fortune in no time. His head might be cut off at any moment even by his most trusted slave. Immediately after the death of the father, the sons of the richest had often to big in the street, for, according to the law the dead man's property reverted to the King. There was no property which the King could not confiscate, there was no life which he should consider sacred. A son could murder his father most ruthlessly; public opinion would be in his favour if he succeeded. He might even be acclaimed as the right hand of God, if he succeeded in patricide. Failure was the only sin that was worthy of punishment. Under such circumstances it was no wonder that the towns

went to rack and ruin. The usurpers established their courts whereever it was safe for them to be. Plunder and extortion brought both women and riches. The court lived in luxury and debauchery. Trade and industry shifted to the precincts of the court. Every one was living for the day. Some built picturesque buildings for their mistresses, and magnificent graves for themselves. Few thought of towns, their improvements and lay out. Even forts built by many rulers had to be abandoned by their successors, for few succeeded to the throne without treachery or murder, and for such the seat of the predecessor spelt death. It was thus even the seven cities of Delhi and several Baghs of Lucknow came to existence. When such was the fate of kings, what could have been the plight of the people?

In towns, the rich and the poor, without the distinction of creed or calling, huddled together in whatever space available, with little thought of comfort or convenience. The rich had their attendants and the poor had their dependants. All had to live together and work. Houses became workshops and sale rooms all combined. The planning of the town according to the need of the people had been forgotten. Consequently towns grew up as they are today a conglomeration of mansions, huts, shops, workrooms and cattle sheds, without regularity, without beauty and without design, in the most congested manner possible. The congestion made the people violate even the primary laws of sanitation and public health.

It was at this stage the British came to India. Their chief concern was to lay out areas safe for their officers, offices and men, as the city was neither convenient nor safe for them. When the Civil and Military administrations were separated these

areas underwent a further sub-division, as the Civil Lines and Cantonments. Thus in every town of any importance three distinct areas came to be: the old town called the City, the most crowded; the Civil Lines the thinly populated; and the Cantonment, occasionally populated. The Civil Lines are mistakenly considered as remedy for the congestion in the city; but they are not by genesis or development. However it is gratifying to note that there is a civic awakening in India; and the problem of the city is attracting the attention of the Government and the governed alike. But the speeding of the civic improvement has been retarded by the preoccupation of both. The political emancipation has become the primary consideration of the people. But it should not be forgotten that the political emancipation has no value without civic amelioration and the right type of the citizens to wield the political power. Every city when it is aesthetically laid out and properly appertained becomes a great dynamic force, which influences the morale and well-being of the people. How this force reacted on the people can be best seen in the ancient city states of Greece. The Hindu Silpi appears to have been fully aware of this. They laid out the smallest type of the Dandaka for the residence o the recluse, who retired from active life. They adopted Swastika for the residence of the kings, Nandyvarta for the Imperial city, Karamuka for a trading centre, and so forth.

In ancient days, in India, not only towns and cities were laid out with deliberation, but remote villages too; some of them still bear the stamp of the expert town planner. There it will be seen that the location of the village well,, the temple, the Council tree with chaputra (or raised platform), the alignment of the processional and cross roads, are all arranged with

deliberation, and not happened to be there by chance. The Hindus looked on the lay out, whether it was of a town, village or house, not only with a sense of beauty and utility, but with a sense of spirituality as well. Even the construction of a well was a sacrament to them. Every village or town had one or more civic centres, which fit in with the daily life and habits of the people. Now-a-days, the civic centres are arbitrarily placed at all kinds of places by the town planners and the city-fathers. Most of them are beautifully built and admirably appertained, but practically unused by the people in general. Why ? These centres are not suited to the habits and disposition of the people. A civic centre nearby a gubernatorial building will naturally be shunned by the people, especially when the Government is not of the people and by the people. On the other hand they collect round in some "Pan-vallas" (beetle leaf seller's) stand, in some crowded part of the city, with stinking drains and steaming abominations all round. For, there they meet their friends, they can buy a "Pan" or "Bidi" get a glass of sherbet, and some sweets-scented flowers to take home to their wives.

In town-planning and town improvement, an appreciation of the psychology of the people is most important. The method of improvement found satisfactory for a commercial town may not suit a religious town. For example consider the overcrowding in Cawnpore and Benares. Cawnpore is an industrial town, while Benares is a religious town. To Cawnpore people go to work and live, while to Benares they go to rest and die. From time immemorial the Hindus have been imbibd with the idea that the death on the river Ganga at Benares is a short cut to Heaven; and this short cut can be further

shortened if death would take place while bathing and praying on the Sacred "Ghats." Whether there is any sense in this belief or not it is not for the town-planner to question. His duty is to remove the congestion and serve the public. This peculiar belief or the psychology of the Hindus made them crowd on the left bank of the Ganges, on a narrow strip of land, which became sacred by association of many sacrifices and acts of austerity throughout the ages. Here the rich, the poor, and the beggars crowded in mansions, houses and hovels, especially with a view to reduce the chance of dying away from the ghat as minimum as possible. While waiting for the death, they had to eat and live ; and to cater for them trade and commerce found a niche among the devotees. In any scheme for improvement of Benares, if this cause of overcrowding is not taken into consideration, it is bound to be a failure.

The civic sense and civic institutions played a high role in ancient India. They ceased to function under foreign domination, though remnants of them can still be traced in places where the foreign influence has least penetrated. With the disappearance of the civic institutions, the civic architect or the Silpi has also disappeared. Our problem, to day is the same as that of the ancient town-planners except for the fact that we have to cope with faster vehicular traffic. The Silpi had to deal with heavy elephant and chariot traffic. We have to deal with the ever increasing speed of motor vehicles. Cross roads and sharp corners may not have given the old city dwellers any difficulty, whereas we have to give preference to curves, bends and easy turnings. The curves and bends were not omitted by the Silpis. Perhaps a study of their methods and application may be helpful to us.

CHAPTER XI

House-Planning

THE term House-planning may sound strange to our ears. But there is a certain branch of the Silpi activities, which I can not express in any other way. We are accustomed to the terms like house design and construction, and also getting used to furnishing and appertaining the house. Though we have felt consciously or unconsciously the need for planning of a house hardly any serious thought has been given to the subject; whereas the Silpis, in days gone by, exercised a great deal of thought on this subject of paramount importance; paramount it is, for, it affects the life of every one whether he lives in a hut or a palace, or whether he works in an office or a workshop.

The first consideration of the Silpi in planning a house was a suitable site, as was in the case of town-planning. Any site was not considered suitable by them for all buildings. The limitation of space was recognised by them, but when it was possible they applied their method of selection with scrupulous care. According to Manushyalaya-Chandrika the best site should have the following attributes :—

(i). It should have a uniform level, but preferably sloping slightly in a suitable direction.

(ii) It must be in a suitable locality, suited to the needs and requirements of the inhabitants.

(iii). The ground should be firm, resounding and fertile. If the sub-soil contained ashes, bones, hair, and husks of grains, such sites should be avoided. The stability and fertility of the soil, should be of acceptable kind.

(iv). The sites with a ridge or hollow in the centre should be avoided.

(v). It must contain milky trees and shrubs.

(vi). If possible one should select a rectangular plot; and plots, circular or with irregular periphery, should be avoided.

To enable one to make the selection of a suitable site, the following classification and qualification of the slopes are given :—

	Nature of slope.	*Name.*	*Qualification.*
(1).	W-high, E-low	Go-Vithi	Wealth giving.
(2).	N-W high, S-E low	Agni- ,,	Wealth destroying.
(3).	N-high, S-low	Kala- "	Death giving.
(4).	N-E high, S-W low	Bhutha- "	Loss giving.
(5).	E-high, W-low	Vari- "	Poverty giving.
(6).	S-E high, N-W low	Sarpa- "	destroying descendants
(7).	S-high, N-low	Go- "	Wealth increasing
(8).	S-W high, N-E low	Dhanya- "	Prosperity giving.

Ground high in the centre causes loss of health, and grounds hollow in the centre cause exodus to foreign parts. The names given to these slopes are mere means of identification no doubt, while the qualities attributed to them are encouraging or discouraging. Adherence to correct slope is further emphasised by holding out prosperity for a certain number of years.

Ground	sloping	down	N-E	ensures	prosperity	for	1,000	years.
"	"	"	E	"	"	"	500	"
"	"	"	N	"	"	"	100	"
"	"	"	N-W	"	"	"	50	"
"	"	"	S-E	"	"	"	12	"
"	"	"	W	"	"	"	10	"
"	"	"	S	"	"	"	8	"
"	"	"	S-W	"	"	"	6	"

Who will not dream of prosperity for 1,000 or even for 100 years and select a suitable slope? It is undoubtedly the Silpi way of enumerating good or bad slope. Why so much attention is given to the slopes? If a slope was preferable on account of drainage facilities any slope in any direction would have been sufficient. There is therefore something behind the slope. Nobody will construct a house except facing a slope, if any; and nobody would care to have his front view marred by gradually rising ground however small it might be. It is therefore abundantly clear that it is the aspects that are considered by these slopes.

In Britain and such cold countries great deal of attention is given to suitable aspects for buildings. A proper aspect is essential to make a house comfortable. In cold countries the aim of the architect is to get as much sunlight and warmth into the house. So they naturally prefer a Southerly aspect. But in a hot country like India the aim of the Architect should be to keep the house cool and to shut off as much of the sun and heat as possible. That being the position the judgment shown by the Silpis, cannot but be admired. Unfortunately, in these days, correct aspect hardly receives any consideration in this country. Architects and designers appear to be quite oblivious to the need for such. Well designed and well constructed houses are often found hotter than old fashioned houses of inferior design and construction. By a mistaken notion, the defects are mainly attributed to the difference in the materials of construction, such as brick walls in place of mud, and concrete roof in place of thatch. Height also is considered to be an element of coolness. Closer examination would show that these are minor elements that affect the coolness or comfort of a house; but the chief element is a

correct aspect that takes into consideration the climate and the prevailing winds. Many old fashioned houses are cooler and more comfortable, the chief reason being that they have been built with a suitable aspect, even though the builder may not have known what he was doing. The aspect which prevails in India at the present time can be easily called "Road Aspect", for every builder shows a desire to face the house on to the road. Due to the mania of facing the house on to the road many a nicely constructed house has become uncomfortable and hot.

I had occasion to supervise the construction of two houses of the same design and specification, but with different aspects. On completion the occupant of one house complained of excessive heat; it was noticed that the drawing-room temperature of the one with a westerly aspect was full 10 degrees F. more than that of the one with a northerly aspect. The second main factor which determines the coolness of the room is the position of doors and windows; in which also Silpis appeared to have shown a great deal of understanding, if one is to judge them from a study of old buildings.

The Silpis had a preference to a square plot, which they designated as Brahmana Plot. The reason for this preference will be obvious from their system of Survey, which was based on dividing the plot into 64, 81, 100 &c. equal smaller squares. But they had not rejected all land that was not a perfect square. The land whose length was one and one eighth of its breadth, they called Kshatriya plot; the land whose length was one and one-sixth of the breadth, they called Vaisya, and the one whose length was one and one-fourth of the width they designated as Sudra. Of course plots of these proportions can be dealt with without much brain racking in their form of mental survey. The names

given to these plots after the names of four recognised castes caused confusion among the later day writers of the Sipla-Sastras and their interpreters; they mistakenly assert that these four kinds of plots are intended for four respective castes, the Brahmins should have Brahmana plot, the Kshatryas should have Kshatrya plot and so on; and some of them go even to the extent of explaining that a greater plot is given to Sudra on account of his cultivating needs. The absurdity of this explanation is easily seen when it is realised what precious little excess a Sudra gets in this fashion. Do the Brahmins realise that they are loosing something by adhering to this mistaken interpretation ?

The Silpi's preference for a square plot of ground did not make them reject all other plots. They took all, but left out portions beyond the square, from their calculation and planning. The first act in planning was to establish a true east-west line on the site. Wherever it was possible to project a true east-west line from an existing neighbouring building, it was done, otherwise a true east-west line was established by setting up the Gnoman, as described in Chapter II. This line they called Brahma Sutra, and was to run through the centre of the plot. Dividing this line into two, and through the centre another line called Yama Sutra was delineated on the ground perpendicular to the Brahma Sutra. They preferred to make the four arms equal and the plot a perfect square; and doing so if they had to leave certain portion of the ground beyond the square, they did so, and separated them by some hedge, fence or wall, as a permanent record of their planning I used to be puzzled at certain unnecessary boundries and demarcations round my ancestral house, in Travancore (of two to three centuries old),

though the land alround the compound bore the same name, (for we have proper names for each compound) and bore the same survey number. It was only after learning about the Silpi ways, I was able to know the significance of those unnecessary hedges and walls; no doubt this was their way of keeping record plans. The names of the four squares created by the perpendiculars Brahma and Yama Sutras are given in Chapter III. Of these N-E or the Isa square is considered by the Silpis the best suited for locating residential buildings; the S-W or the Nirirthi square for Temples and public buildings while both the S-E and N-W squares were to be avoided as a rule, though in exceptional cases certain particular kinds of buildings could be erected in N-W squares. But, for reasons such as nearness to a stream or river, cultivated fields or rocks, if the N-E square could not be selected, the residential buildings can be made in the N-W square. It is stated that the residential buildings in the N-E square ensures prosperity, those in the S-W square fulfil the desires, and those in the S-E square bring about death. These are again injunctions to induce people to select squares considered suitable by the Silpis. Their reasons for acceptance or rejections of particular squares are not forthcoming; however, it appears that there are certain reasons behind these injunctions. Adherence to this rule of constructing houses only in the N-E square, would leave a continuous open space on the hotter side of the house, namely south and west, where trees and shrubs could be planted with advantage to make the incoming hot air somewhat cooler, and to ensure greater privacy. If these injuctions are strictly followed, any place in fact, will become a veritable garden city. The Malabar Coast was a garden city of this kind.

According to some authors, the selected square should be divided into 64, 81 or 100 smaller squares, and gods should be placed as shown in the diagrams 7, 8, and 9 and the centre square marked Brahma should not be built upon. This rule does not appear to be all correct. It is stated in Manushyalaya-Chandrika that the length as well as the breadth of the square should be divided into 18 equal parts, thereby making 18 × 18 =324 smaller squares. These are then treated into Vithis. Vithi may mean a strip. These Vithis run lengthwise and breadthwise into square strips with the width of each equal to one-eighteenth of the length and breadth of the selected corner square. In diagram (25) these Vithi divisions are shown. The outer Vithi that runs round the four sides of the square is known as Paischa Vithi; the next ones in order are known as Deva, Kubera, Yama, Naga, Jala, Agni, and Ganesa, while the innermost portion consisting of four small squares is known as Brahma-Vithi. Of these Vithis the Paisacha, Yama, Naga, and Agni should not be used for any kind of building. The Vithis Deva, Kubera and Jala are to be used for out-houses, and such like. The Brahma square is specified for the main house, and if the house is too big to be contained in this square, the next Vithi, the Ganesa Vithi can also be utilised. But under no circumstances the main building should go over to the next Vithi, namely the Agni Vithi. The proper names given to these Vithis are for the purpose of identification mainly, but at the same time the names given to them have a deterring effect; for Paisacha means satanic, Yama signifies death, Naga or snake is associated with terror and Agni is associated with fire or destruction. The recommended Vithis on the other hand have alluring names, for Deva means angelic,

Kubera wealth giving, Jala means water, signifying plenty, while Ganesa and Brahma are names of the high gods of the Hindu pantheon.

The Vithi system, contradicts the main squaring system, for according to the sixty-four squares the four divisions of the Brahma square in the centre and according to the 84 division squares system, the nine squares in the centre, and according to 100 squares system, the sixteen squares in the centre are to be left out without any building; on the other hand the Vithi system permits the construction of the main house partly in this prohibited area. So both cannot be correct. Some ancient and modern annotators of the Silpa-Sastras seem to have made abhortive attempt to justify both, but their failure appears to be due to one or both of the following facts. First they considered the Silpa-sastras were of divine origin and as such no mistake can be in them. Secondly they failed to understand what was the real significance of both the squaring and the prohibitions. If they had realised that the squaring was a simple system of surveying and not to find abode for the gods, and the prohibition of certain areas was the early introduction of the building bye-laws, they would have been successful in their attempt. Apparently the Vithi system is intended for laying out a house in the selected portion of the compound, while the other squaring system is for laying out a town in a vast area, and the allotment of space for the buildings should be differentiated from the allotment of areas for open spaces, parks and such like.

Among the Malayallee Silpis, it seems that there is an inclination, rather a bias for dividing the plots into 81 divisions; it is due to its affability to fit in with the Vithi divisions. The

combined Vithis of Brahma and Ganesa occupy about one-twentieth part of the whole area, thereby it introduces a bye-law restricting the area to be built upon in relation to the area of the whole compound. The need for such a bye-law is long left among the town planners and Municipal councillors, especially in recent years in India. It is being introduced, though not on such a generous scale as that of the ancient Silpis. Among other auspicious Vithis, Jala Vithi is intended for subsidiary buildings ; and Deva Vithi is for out-houses and servants quarters though a portion of them is only built upon, except in case of palaces and public buildings. The outermost Vithhi, the Paisacha is not to contain any building. It is a very sound principle. A glance at the so-called Civil Lines of modern development with the congested servants quarters and out-houses, built in line with the boundary, would convince one of the soundness of this principle. The injunction against any building in Yama and Naga Vithis ensures a clear space between subsidiary buildings and servant quarters, which is also very commendable from health and sanitary points. The prohibition against buildings in Agni Vithi may have a great advantage in case of fire in segregating the affected portions from the rest.

To lay out any building by this process is very simple. First make a note of the available area of the land. Fix the length or east-west dimension; if it is greater than the available width, cut off a portion of the length to make it equal to the width though only for the purpose of laying out the building. Then take half the length of the land, if extensive, do not take the whole length, divide it into 18 equal parts. In fact even a measuring tape is not required for the purpose, a rope or string

of sufficient length will suffice. Fold the string into 18, which will give the width of the Vithi. Then establish the central or east-west line on the ground; then with the help of a few pieces of strings and some pegs the exact location of the buildings can easily be made. After having done this the exact foundations can be marked out by a measuring rod.

This system may be considered as steriotyped; it may curb even the discretionary powers of an architect, but it ensures uniformity, and serves the public interest, which after all is the intent and purport of any code of building bye-laws. If the land available was not extensive, it was permissible to omit the first division of the land into four squares, and the Silpi was allowed to start the Vithi system straight away, taking the whole land as one square. The average minimum extent of land below which the primary four divisions could be dispensed with, according to some authority, was 18 Dandu, or about 108 feet square. The above rule was made still more lenient in towns and cities, where the land was still more scarce. There it was permissible to treat the whole area as the Brahma plot and Ganesa Vithi combined; but it was enjoined not to build on the entire area, and as far as possible to confine the main building on the North-east quarter and leave a fair portion as open space or outer yard.

After selecting the plots for construction, it was enjoined to fix the "Marma" of the ground. "Marma" is the name given in Ayurveda (Hindu Medical Science) for certain vital points in the human body. The Marmas of a plot of ground divided into 81 squares are shown by black spots in the diagram (26). Here ten perallel lines are drawn east to west and ten par llel lines north to south as perpendiculars to the former,

making the plot into 81 equal squares. These lines are called "Nadies", again another physiological term, meaning the medium through which the vital fluid is circulating. Then the first two diagonals to the main square are drawn; secondly four sets of minor diagonals parallel to each of the above are drawn. These are called "Rajus". The meeting points of these Rajus with the Nadis, and the Nadis with Nadis, are known as Marma; but not the meeting place of one Rajus with another Rajus. Thus there are 100 Marmas in a square divided into 81 divisions. In these points it is stated that no walls, pillars etc. are to be erected ; while the eight points where the eight Nadis and Rajus meet are points of special attention, and on no account anything should be erected there covering or obstructing them. If these injunctions are violated all kinds of serious consequences are predicted, and the severity of them according to the nature of the offence. Death is held out for violating the four points A, B, C, D, while for others calamities of a less serious nature.

What is the meaning of all these ? It looks absurd from the very face of it. Marmas or Vital points in a human body one can appreciate. But how can such Vital points be in a plot of land, especially when such shift about according to the nature of the divisions into which the plot is subjected. When a plot is divided into 100 squares, its vital points cannot be at the same spot where the vital points should be when it is divided into 81 squares. The Silpis were undoubtedly influenced by the assignment of Vastu Rakhsasha on the plot in calling these points Marmas and the lines Nadis. However, it is not impossible to form a correct idea about these points from what is further stated about them in certain texts.

The injunctions are decidedly emphatic; but the space to be avoided at these points is very small. It is stated by some authorities that there should be no obstruction about these points to a distance of about one twelfth of a division to the east and the same distance north of the point; that is for a plot divided into 81 squares. When it is divided into one hundred squares, one eighth of a division and when it is divided into 64 squares one eighteenth of a division should be left without any obstruction. Others are of opinion that a uniform space of about one twentieth of a division should be left irrespective of the number of squares into which the plot is divided. So when the plot is divided into eighty one squares and the length of the plot is say 108 feet the clearance about the point is 0.6 of a foot. This clearance may be for the purpose of taking a line or string through the point, for the purpose of checking directions or measurements, during the process of construction, and afterwards in considering extention or alterations. As we possess accurate scientific instruments to-day, we may not fully appreciate the need for leaving out such a space or clearance, as we could overcome any difficulty through obstruction by means of a theodolite. It should be remembered that the Silpi had no such instrument; hence they had to leave a "peep hole".

Further the rule about the Marmas is not inviolable. The Marmas can be disregarded; and they need not be observed in certain cases. For instance when the whole area is built upon, the Marmas can be violated; that is where there is no chance of extension. Even in other cases the Marmas can be violated if necessary, provided certain propetiatory rites to gods are performed. What is the nature of the propetiation ? A golden image with five heads has to be established at the spot. If these

five heads are to be five arrow marks and if they are suitably adjusted and placed outside the violated Marmas, the directions of all the number of lines that may meet in any point can be picked up, though the point at which they meet is hidden. As the maximum number of lines that would meet any Marma is eight; five suitable arrows or heads marked will indicate all the eight directions. According to the texts the placing of these images are to ward off the evil consequences of violating the Marma, but in fact the whole action is akin to the practice of indicating fire-hydrants and underground sluice valves by directions given on adjacent walls on the road side. The full importance about the Marmas and the restrictions can only be appreciated if one could place himself in the position of a builder who is called upon to carry out additions and alterations to a building, without any plans of the existing structure or lay out and with obstructions in the way of tracing the original lay out, and with no instrument such as we use at present. If the explanation given above is acceptable, it will be seen that these rules and restrictions introduced by the Silpis in ancient days are not without their utility, though their descendants have forgotten their real significance.

The Hindus in ancient days had peculiar ways of keeping records. A battle field like one at Kuruksetra is commemorated by an annual gathering or a mela, on the spot. The place of a "Sati" or widow burnt herself to death, is commemorated by a brick column. The burial place of a "Pahan" (or the head of certain aboriginal tribes) is marked by an upright stone slab. Extraordinary, high flood levels are marked by a plinth level of a newly erected shrine. Many instances of calamity and special occurence are marked by special symbols or struc-

tures. If these dumb records could speak many obscure passages in Indian History would be unfolded.

Opinions differ as to the extent of the ground to which Marma division or the division for the purpose of determining Marmas, should be applied. Some authors suggest that the whole compound should be subjected to this treatment, while others are of opinion that only that part of the ground to which the construction is limited should be taken into consideration. If the object of the procedure is, as is expounded above, it is obvious that the section selected for the buildings should only be treated in this fashion.

In planning the house it is enjoined that a certain space called "Ankana" is to be left without any structure. In fact Ankana or Ankan is the main feature of the Hindu lay out. It can be traced back to the aboriginal tribes like Mundas and Oraons and Asuras as well, who are more primitive than the former. They scrupulously leave and designate an open space as Ankana in front of their most modest huts. It can also be traced back to Mohenjo-daro. The Oraons and Santhals have the main hut facing the Ankana, kitchen and cattle shed on either side facing the Ankana. Ankana, which might have originated in providing an open space in front of the house, gathered importance when more than one side of the Ankana began to be built upon, and that importance became foremost when the buildings on the four sides had to be connected together leaving an open space in the centre, and when the external and internal beams of the four-side buildings have to be connected together by prefabricated wrought wood. Hence the Silpis on the Malabar Coast where the houses are chiefly made of wood, give extreme importance to the design of the Ankana. When the house

is built of masonry the design of the Ankana may not receive such importance as the adjustment of the walls and roofs can be made during the process of erection; but the wooden houses of the Malabar Coast are prefabricated like steel structures, left only to be assembled at the site. Fabricated structures are sold, and the purchaser removes them from the site and re-erects elsewhere. In like manner the wooden houses of the Malabar Coast, that are built by the Silpis are sold, dismantled from the original site, and re-erected at other places, with only new foundations to be provided at the new site. Hence the Malabar Silpis start with the design of Ankana first.

The Malayalee Silpis seldom design the Ankana as a perfect square. Having determined the circumference or the perimeter of the Ankana from the incidence of the survey and the size of the buildings, they determine the length and breadth with the use of any of their standard proportions, given in Chapter V. The perimeter of the Ankana should either be in I or V Yoni. Or the perimeter in Kols multiplied by 3 and divided by 8 should leave the remainders 1 or 5.

Of course the Ankana should not be designed without taking into consideration the size of the buildings that are to be about them. There are two Ankanas, one is the "Madhya-ankana," the square between the four-side buildings, then the Bahya-ankana, the yard outside the four buildings. This outside ankana should also be of the same Yoni as the inside Ankana. The Ankana that is the inside Ankana, may be built on all the four sides. If one side is only to be built upon, it should be first decided whether it is to be on the south side or the west side or one of the most suitable sides. This would entirely depend on the ground or suitable aspect. If the northern aspect

is preferred, then the main building should be built on the south side of the Ankana, if further extension is required the next building should be on the west side of the Ankana; the next one on the East and the last one on the North. On the other hand if an Eastern aspect is selected, the priority should be given to the building on the west side of the Ankana, the rest of the buildings in order of priority and construction are to situate north, south and east. It is also strictly enjoined that the width as well as the height of these buildings should be according to this order of priority. A less important building situated on a less important side of the Ankana, should not have its height greater than that of a more important building, and a less important building should not be made double storied while the important building is single storied. It may be mentioned here again that the height of a building according to the Silpi practice is proportionate to its breadth, the greater the width the greater the height. The building on the west side of the Ankana is called west Graha, on the south is called south Graha and those on the north and east sides are called North Graha and East Graha respectively. In addition to these it is permissible to have four Grahas on the four corners, which are called "Con-Grahas" or corner buildings. But it is not the usual practice to construct con-grahas separately in a living house, though for public buildings, it has got its advantage, the con-grahas are taken with the main grahas in design and construction. The South-west con-graha is taken with West Graha and it must have the same width as the west Graha; and the roof, walls and beams contiguous. The N-E con-graha is taken with the East Graha, the S-E with the South and N-W with the North Graha. The unbuilt portion or the passages

between the four blocks are as shown in diagram 27. (A) where the main building is shown in the west. If any joining of the building is to be done in this instance, first the south block should be joined on the west then the north block to be joined on to the west block; and lastly the east block to be connected on to the south and north blocks.

The clearance left between the blocks is to serve as a passage no doubt but it may have some other motive as well. It appears to me that it is chiefly intended to control the circulation of the breeze in the Ankana, and consequently into the buildings. By the arrangement as above it will be seen that the full force of the hot wind from the south is obstructed by the south block and a portion of it is led through the south-west passage into the Ankana where its course is obstructed by the north block and deflected towards the east to find an outlet through the north-east passage. Similarly the wind from the west after getting access to the Ankana through the North-west passage and being deflected by the east block finds its way out through the South-east passage. But the winds do not blow exactly from any cardinal point and it is only a fraction of them that find their way into the Ankana at a reduced velocity, with less dust or shower. If these passages are not there, and all the four blocks are connected together with blank walls then when it is blowing outside, it will be very uncomfortable in the Ankana. Even when all the four blocks are joined together as in diagram 27. (B) the Silpis leave such air passages. These passages they call "Antharala" or halls. But it will be noticed, from the same diagram that the position of these halls do not coincide with that of the passages. Perhaps the position of the Antharalas was fixed on mature consideration and it appears to be the best, as it imposes further

restriction on the passage of the air into the Ankana. Ankana should be considered as the roof-less living room in a house. It has verandahs on all four sides, which not only give access to the rooms on the four sides, but enhances the utility of the Ankana as a living room in all kinds of weather conditions. If there is any breeze from any direction the Ankana will have its share, what a blessing it is when the hot weather changes into rains. It might even be for the purpose of making the Ankana and the house more comfortable that they determined different height for different Grahas. It will be seen that the high roofs as ordained are in the direction of the high and uncomfortable winds, such as the "loo", Monsoon etc., the high roof on the one hand obstructs hot winds and Monsoon, at the same time they deflect cold north winds and make them bearable as they drop down into the Ankana. The high buildings on the south and west also make the house cooler by keeping off the hot sun. If these are as presumed above the Silpi planning is excellent and suited to the climate and conditions in the country. Diagram 27 (C) shows a mixed lay out.

The Silpi planning has practically disappeared from the country, and its place is taken up by the so-called up-to-date planning, which some people call the western planning. It is neither up to-date nor western. The present day houses are lacking in many respects. One of the chief requirements in a house is privacy. A person needs at least a corner in the house where he could be away from the gaze of the others, and where he could be quite alone at times, or in other words what one calls a corner of his own. The "up-to-date" bungalows generally do not afford this requirement. You are more often than not, exposed

to the roads, servants or neighbours. The doors and windows are arranged in such a way that privacy is out of the question, even in the innermost recess of your private apartment. Of course it may be argued that the doors and windows are arranged in such a way as to get an unrestricted blow of air into the rooms. But how many months in the year and how many days in a month an unrestricted blow of air can be allowed into a room, without being suffocated by the dust-storm, without being scorched by the hot air, without being drenched by the showers, or without cold blasts penetrating into the marrow of your bones ? Careful statistics taken in this direction will be a great guide for future builders. Further a draft of air through a room is no criterion as to the efficiency of ventilation. Proper ventilation depends on the velocity of the incoming air, and the renewal of the air in the respiratory area of the room. The Silpis seldom allow through ventilation. They arrange the doors and windows in such a way and at such places as to ensure a bearable temperature as well as the renewal of the air.

The Silpis used to pay great attention to plinth, which the present builders avoid as much as possible probably based on a false idea of economy. The height of the plinth or "Pitha" should be proportionate to the height of the columns or the height of the wall to the beam level. The proportions may vary according to the nature and type of the elevation, however the maximum height of the plinth is about one-third the height of the column. A high plinth not only presents a good elevation, but it makes the verandahs useable when the rain falls. The Silpis were not content with providing a high plinth alone; in localities where there is heavy rain, or the ground is low and water-logged, they provided a secondary plinth below the main

pl nth and above the ground level, which they call "Upa-Pitha". The height of the Upa-Pitha is generally about one sixth less than the height of the plinth. The secondary plinth not only covers the buildings, but it covers the yards alround, or the "Bahyankana" as well. This remedies a great deal the trouble from insects and creeping abominations that are abundant in a climate like that of India.

CHAPTER XII

Sculpture

THE earliest sample of Sculpture in India was found in the Indus Valley. Two stone statuettes were found in Harappa of the 4th Millennium B.C. Fig (1) represents the fine figure of a man done in red stone; Fig (2) represents the dancing figure of a man done in grey stone, which according to Sir John Marshall may be taken as the forerunner of Nataraja, or Siva in cosmic dance. About these two statuettes, Sir John Marshall states thus:—"When I first saw them I found it difficult to believe that they were prehistoric; they seemed so completely to upset all established ideas about early art. Modelling such as this was unknown in the ancient world up to Hellenistic age of Greece and I thought therefore, that some mistake must surely have been made; that these figures belonged to the Indo-Greek, Scythian or Parthian period in the Punjab, and somehow or other had found their way into the levels some 3000 years older than to which they properly belonged." Though this was his first impression, Sir John negatived the possibility of their Hellenistic origin on the following grounds :—(1) these stones were not the medium of the Hindu-Hellenistic sculpture, and (2) certain techenique in them was "without parallel among the stone sculptors of the historic period, whether Hindu-Hellenistic or any other school". The exceptional techeniques are :—(a) the attachment of the head and arms by means of socket holes in the neck and shoulders, (b) fixing of the independently made nipples of the breast in

cement, and (c) the predominent abdomen, which is characteristically Indian and not Greek.

To establish further their Indian origin and set aside the possibility of their Greek Origin, Sir John Marshall further states as follows:—"Of the influence exerted by Greek art in the North-west of India, there are hundreds of examples among the sculptures of the Scythio-parthian and Kushan period; but one and all are radically dissimilar from these two statuettes; they give us the form and not the substance of the Greek Art. Superficially they call to mind the Hellenistic prototype of which they are to some extent transcripts, and they possess beside many merits of their own, in which Hellenistic inspiration had no part. But they miss altogether that characteristic genius of the Greek which delighted in the anatomical truth and took infinite pains to express it convincingly. Now in these two statuettes it is just this anatomical truth, that is so startling; that makes us wonder whether in this all important matter of Greek artistry could possibly have been anticipated by sculpture of a far off age, on the banks of the Indus. We know definitely that the Indus engraver could anticipate the Greek in the delination of animal forms; and if we compare the statuettes of PLX with the seal 37 (the Bull) we must admit that there is a kinship between the two, both in the monumental treatment of the figure as a whole and in the perfection of their anatomical details. Experienced sculptors whom I have consulted on the subject take the view that an artist who could engrave the seal in question would have little difficulty in engraving the statuettes." The bull is shown in Fig (3)."

The next objects of sculptural excellence, that are available for us, are the capitals of Asoka's pillars; among them that

one at Sarnath dates from the third century B. C. But Asoka's pillars and their workmanship are described as of foreign origin. Some are of opinion that the Asoka's Imperial Ensign is a copy of the Persipolitan pillars; and borrowed from the originals, the specimens of which are still to be found in the planes of Murghab and at Itakhar, Nateshi-Rastam and Persipolis; and the imported craftsmen from Greece or Persia executed them. A strong argument in its favour is the presence of the honey-suckle ornament at the capital of the lats at Allahabad, Sankisa (between Muttra and Kanauj). The honey-suckle ornaments were used by the Greeks, with the Ionic order of their Pillars, which they borrowed from Assyria; and the Indians are supposed to have borrowed it from the Greek through the Persians. Could not have the Indians borrowed direct from the Assyrians, whose respective countries had commercial or cultural contact since prehistoric days? Could not the Indian Silpis have carved this out, without any inspiration from the Assyrians? Were the Indian Silpis devoid of originality in designing natural and imaginary objects? These questions should be answered by those who state that the honey-suckle ornamentation of Asoka's Pillars came from Persia. But the "bell shaped" appearance of Asoka's Capital is not bell shaped at all; it is admitted now that the bell is the turned down petals of the lotus, which the Hindu Silpis use with advantage for multifarious purpose. Then the Lat itself: Has it come from Persia? It is more likely that the lat is the "dwaja" of the Hidu Temples. Dwaja is a flag-pole, in front of the Hindu temples, to hoist the flag during annual ceremony of "Utsava". Utsava lasts for eight or ten days. The dwaja is made of a uniform stem of some suitable trees; and in some places the stem of the arrecanut palm is used on account of its evenness. The height of

the pole is a certain multiple of the height of the image in the temple. The dwaja has a triangle fixed at one side, from which a flag flutters. The Capital of the dwaja is always mounted by the carved figure of an animal, the animal favourite to the God of the temple. God Vishnu has the image of Garuda, king of the birds; Siva has the Bull; Goddess Bhagvati has the lion, Subramanya has the peacock, and so on. Often this periodic dwaja is substituted by permanent one made of stone, or hard wood, encased in copper drums plated with gold or silver. These kind of dwajas are seldom seen in North India, where they often fix a pole on the top of the shrine itself to attach a permanent flag; but they are common in the south.

It is more than likely that Asoka looked at the Dwaja-stambha (flag pole) for a suitable object to record his victories and proclaim his faith rather than sending some one all the way to Persipolis, which was not opened for easy traffic, despite Alexander's invasion. However might it be, Asoka would not have hesitated to find out through his emiss·ries what was worth adopting from the foreign countries without caring whether the critics of two thousands years hence would split hairs about his adoption of such, and condemn the whole Indian Art as imitation from foreign countries. But it may be mentioned that the Buddhist emissaries of Asoka were not specially admirers of art and craft, they were but ascetics, who renounced the world with everything' what it stood for.

Whether or not the Asokan Art was of Greek or Persian origin, there is nothing against its bieng considered as directly descen-ded from the long buried Indus Valley art, though the inter-

vening period between the two was over three thousand years. Time does not obliterate tradition, unless tradition is given up by the people themselves through forgetfulness or suppression by invaders. During this period, though there were invasions of India, the invaders instead of obliterating Hindu culture and traditions, adopted the Hindu ways of life, and became super-Hindus. It is stated by Rene Grousset that "If we compare the animals zebu, elephant etc. of Saranath or even those of the gates at Sanchi dating from the first century B.C. with the corresponding beasts at Mohenjo daro, it becomes hard to banish all idea of a distant relationship between them. Do not the seals of Mohenjo-daro already display one of the essential merits of classics Indian art, that is a naturalistic treatment of animals characterised by a wonderful breadth and flexibility?" The relationship between the Indus Valley art and the Mauryan art may not be so distant, as observed by Grousset, if the gap between the two can be built up. The upper levels of Mohenjo-daro are centempraneous with the latter part of the early Dynastic period of Babylonia, of 2550 B.C. and the earliest authority on the Hindu sculpture Sukra Acharya flourished at the latest about 2050 B.C. The first of these dates is based on Mesopotamian chronology, while the latter is based on the most pessimistic geneological figures given by Pargitter. The difference of 500 years, between these two, will become much less if the Babylonian Chronology is brought down to a later period or if Pargitter's computation is increased above twelve years per generation of kings.

Sukra Acharya, or Usanas Sukra, as a great authority on Hindu sculpture, is quoted even today by the Hindu Silpis. His works on these subjects is known as Sukra Nithi. He was a Dravidian and

a Brahmin, who always sided with the Danavas, (Dravidians) against their battle with the Aryans, or Ailas. He was a great sage and ascetic, though he had a weakness for strong drinks. He is reputed to have raised the Danavas killed in battle by the Ailas or Suras. Yayathi, the great king of the Ailas, while hunting in the precincts of his kingdom, met Sukra's daughter, Devayani, fell in love, and married her. This appears to be one of the first interclass marriages, mentioned in the Puranas, between a Brahmin girl and a non-Brahmin groom. One result of this marriage was the softening of Sukra's heart towards the Aryans. Tvastar, who represents one of the orders of the Silpis (See Chapter XIII) was a son of Sukra. It is not known where Sukra hailed from, the Puranas are silent on this point, but his brother or cousin Cyavana, one of the most prominent ancestors of the powerful Brahmin family of Bhargavas, was always connected with Anarta, the present Gujarat, near the gulf of Cambay, and he is said to have performed austerities near Vindhya mountains and the Narmada river. Sukra must also have belonged to the same region as his cousin. The distance between Anarta and Mohenjo-daro is only 300 miles as the crow flies. The distance, therefore, between the Mohenjo-daro and Sukra Nithi art can be stated as 300 miles and 300 years, which cannot be considered as considerable, when art and culture are concerned. Sukra was undoubtedly a Dravidian, so was Mohenjo-daro Art. Sukra's name, as an easily irritable Maharshi (great sage) is even to day a by-word in the Hindu homes, even where the great king Asoka's name has not penetrated. The later Brahmans, who became the custodians of the Vedas, and the henchmen of the Aila kings tried to hush up Sukra's name, but his name is still fresh (after a lapse of four thousand years) in the memory of the people;

and his directions are respected and followed by the art loving Indians.

Sukra laid down in his "Nithi" what was the Hindu Ideal of Art and Sculpture. Art for the Hindu Silpi is not the imitation of nature; it is the self expression of the artist, in confirmity with certain rules and traditions. Sukra states as follows: "Let the imager establish images in temples by meditation on the deities who are the objects of his devotion. For the successful achievement of this yoga (union) the lineaments of the image are described in books to be dwelt upon in detail. In no other way, not even by direct and immediate vision of an actual object, is it possible to be so absorbed in contemplation, as this in the making of images." The yoga or the union mentioned above is obviously the union between the artist's concentration and the object of concentration. "The purpose of the Yoga," says Ananda Coomaraswamy, "is the mental concentration carried so far as the overlooking of all distinction between the subject and the object of concentration; a means of achieving harmony or unity of conciousness." Preparatory to this concentration, fast, purification and prayer are enjoined, so that the concentration can be effected to a finality. One set form of prayer may be stated as follows :—"O Thou, Lord of all Gods, teach me in dreams to carry out all the work I have in my mind."

The Yoga or union enjoined by Sukra is said to have been strictly followed by sculptors who designed even Buddha and Bodhisatvas. The Buddhist literature gives evidence to this, wherein it is stated that artist after ceremonial purification, is to proceed to a solitary place, to invoke Buddha and the Bodhisatvas even with "poojas", then to place himself in the four infinite moods of friendliness, compassion,

sympathy and impartiality, preparatory to meditate upon "Sunyata" (the non-existence of all things), or make his mind a perfect blank. From the Sunyata stage of absorption he is to invoke the desired divinity by utterance of "Bija", (mantra or prescribed sound and words), and identify himself completely with the divinity to be represented. When Yoga, such as this, is done with due deliberation and due concentration the divinity would appear before the artist as if in a dream or conscious reflection; and "this brilliant image is the artist's model." What a difference there exists between the Silpi model and the model of other artists? The model of the western artist generally is what he picks up from the street on account of the model's look, shape, or expression, which the artist may percieve or seem to percieve; while the Hindu Silpi creates his model by mental absorption and perception. The Silpi creates what he has seen in his vision, though his actual execution is constrained by established proportions and traditions. The western artist gets the inspiration from the model, though he makes additions and deductions to what he sees in the model, so as to justify the saying that art is not the imitation of nature, but the concealing of it. When this fundamentality of the Indian art is realised, there will be no room for any discussion about the influence of Greecian or Persian art on Indian art. The Indian craftsmen may have borrowed materials or tools even from outsiders, just the same way as their descendants have taken to Portland cement and Violin, but it is more than doubtful that they made a change in their conception or design. The ideals enunciated by Sukra, some four thousand years ago, have been cherished and maintained by the Silpis through ages, whether they were Vaishnavites, Saivites or

Buddhists. In the sphere of art and architecture, Sukra Nithi and Maya-Mata still prevail, despite foreign invasion, internecine quarrels, political up-heaval and economic changes. When the Indian art is viewed with this background, most of the inexplicable features may become as clear as the daylight. Take for instance the Images of Buddha that are found in and about India :—

(A) *Buddha of Gandhara,* or Afganistan dates from first century Fig. (4) This Budha has :—

(a) a nice round and smoth womanish face.

(b) his hair done in a way which would give credit to a twentieth century hair dressing saloon.

(c) shorter lobes of ears, when compared to other Buddhas.

(d) a garment in which he is completely wrapped, probably indicating the cold of the country of its origin. His legs are not visible enough to determine whether he is sitting cross-legged, or in any one of the conventional "Asanas".

(e) He is poised on a narrow seat of lilly or lotus, like Brahma, but with unusually pointed petals. The seat in relation to the image would remind one of a "sadhu" sitting on a seat of pointed nails.

(f) His hands are said to be in "Dhyan Mudra", but they seem to be in a posture of hesitation.

(B) *Buddha of Anuradhapura,* Ceylon dated 2nd century Fig. (5). In this Buddha, the following details may be observed :—

(a) He has the vigorous figure of a manly youth, and the conventional long arms of a prince. His face looks a bit sunken, due to austerities.

(b) His posture is said to be in "Samadhi", and undoubtedly it is in "Samadhi", where the individual looses himself in contemplation, and meets what he has been seeking. It will be noticed that in this attitude of contemplation all the standard postures preparatory to "Samadhi" have gone, the legs are not in "Padma-asana, but the right leg shows that he was in "Padma-asana"; the hands are not in any conventional mudra; probably both the hands and legs became loose from their conventional positions, as the soul reached beyond all conventions.

(c) His hair is in a conventional fashion peculiar to a "Yogi", but his coiffeur is not done at all.

(d) No lotus or lilly gives him a soft seat; but he is sure of his foundation; and the whole impression that emanates from the image is that of strength, courage, determination and nobility.

(C) *Buddha of the Ajanta Cave* IX dated 4th century—Figure 6.

(a) This Buddha sits in a most uncoventional form of a Yogi. He sits on a low seat with the legs down.

(b) It can be said that his hands are in "Dharma Chakra Mudra" but they are raised and not low as in the case of the Buddha of Sarnath (below).

(c) This is the figure of a man, who is beyond the prime of life, who could get into "Samadhi" without recourse to the usual "Asanas", and get in touch with the universal soul at pleasure, even when he is surrounded by the desciples or seekers after truth.

(d) He has long lobes of ears, practically touching his shoulders. His hair is done in a conventional manner with a top knot.

(e) He is practically naked. He does not appear to be fasting or starving.

(D) *Buddha of Sarnath, Benares* dated 5th century Fig. 7.

(a) This is the figure of a youth of about 25. He looks healthy, and broad shouldered, like a warrior.

(b) He sits in "Padma-Asan", with hands in "Dharma-Chakra Mudra". His attitude is that of a seeker after truth, which may not have come to him yet; but he looks hopeful.

(c) His hair is done in the most conventional Yogi manner; the lobes of his ears are very long.

(d) He has a firm and solid seat, and a hallow round his head.

From these it would appear that though Buddha was a historic personage, his portraits are not identical, his features are not the same, though his different postures and gestures may be attributed to different moods and time. It was not the Historic Buddha that the sculptors and painters depicted through centuries, but a Buddha which each sculptor may have perceived in his artistic vision or yoga. None may not have known what the historic Buddha was like, for Buddha died sometime during the Fifth Century B. C., and his images began to appear probably during the early part of the first century A.D. No doubt Buddha is an artistic creation of the Hindu Silpis, in the way they created their Vishnu, Siva or Kali. It is true that they did not give multiple heads and hands to Buddha, like those given to their other gods; it was because Buddha was a human being like many of their Rishis or saints, to whom they did not give many arms or heads. Apart from this exception they deified Buddha to the fullest extent, as is seen from the Jataka story sculpture. In narrating every incident in the life of Buddha on stone or marble, or in paintings they had only followed the practice of their picture story

depictions of Puranic tales and historic events. From many a temple sculpture the entire story of the Puranas can be rewritten. Even to-day there are Silpis who could do this kind of work, even without deviating an iota from the old traditions. In Travancore there are certain temples dedicated to Goddess Bhadra Kali, where annual carnivals called Bhatayeni, or Bhata-Srenis are held. Bhata means soldier and Sreni means collection, so these carnivals appear to have had a military significance, in remote days. At these carnivals in addition to various effigies of animals and Puranic personages, often what is known as "Theru" or "Ratha" is produced. These Rathas contain many exquisitively carved images in wood depicting some or other famous stories from the Puranas. The whole story of the Ramayan is depicted in ten or twelve carvings, similarly the Krishna's marriage with Rukmini is shown in eight carvings. These carvings bear comparison with the famous stone carvings of the olden days, and the way the story depiction is done is most remarkable in its brevity and diction. Alas this sort of carnivals and carvings have practically disappeared. These were occasions for the revival of Indian sculpture and decorative art, but they are discouraged and discontinued under a false notion of western cultures.

Representation of an image in different Asanas, and in different Mudras is not anything peculiar to Buddhism. It is part and parcel of the Hindu Art. Asanas come under Natya or dancing, and Mudras come under acting. The Great authority on the subject was a sage called Bharata. He should not be confused with the great king Bharata, who was the son of Dushanta of Kalidasa's Sakuntala. Bharata's Art of dancing exists in fragmentary form in many a country dance; but his science of acting is fully preser-

ved by the Katha-Kali artists. According to Bharata Natya there are 64 Mudras or main gestures. These Mudras are formed by slight bending of the fingers, at the second knuckle, with responsive action of the thumbs. With the bending of the first fingers 16 Mudras are formed, similarly with the bending of the other three fingers sixteen Mudras each. In addition to these sixty four basic Mudras, there are several minor Mudras, which the Kathhakali artists called "Potikai". By the use of the basic Mudras alone, the whole field of acting cannot be done, in which a whole narration is involved. Though these minor Mudras are also based on traditions, there is plenty of scope in them for the actor to exihibit his talent and individuality. But action by the hands alone is not complete, without corresponding movements of the eyes, limbs and body, to acquire which an artist may have to spend some three years in training. A posture in Samadhi (devotional attitude) is done with the entire combination of the body, muscles, eyes and gestures. So is the representation of a love scene. When viewed in this light, some of the images of Buddha are master-pieces of this art.

Fig. 8 shows a Bodhisattva from Borobudur. In this, Bodhisattava is asking his father's permission to depart. Undoubtedly Bodhisattva here is in a Kathha-Kali pose, rendered in stone. The expression on the face is one of tenderness and devotion. The Mudras by the hands show purposefulness and determination, which Bodhisattva has already formed. The whole attitude exudes vigour, strength, gentility and upbringing. No Silpi, but a Hindu, who knew the art of Bharata Sastra, could portray the traditional humility of a son towards his father and the determination of a prince, as is shown in this carving.

All the images of Buddha like all the other images of Gods, Yakshis, Kinnaras etc. have been made according to the Silpi cannons. When the Silpis turned out so many images throughout the length and breadth of India, that was by nature as well as by conquest, if some of them resembled similar articles elsewhere, in Greece or Persia, that in itself should not be considered as evidence to establish foreign influence on Indian Art.

The disposal of hands has always been a problem with the artists and even with the photographers. But the ancient Silpis disposed the hands in an ingenious way in Mudras, or placing objects in the hands, which added to the disposition of the image. Even when they gave more than two hands to their Gods or Goddesses, they supplied them with objects indicative of their power and disposition. Therefore one will see Nata Raja with a small beating drum in one hand, to call the attention of the people to a book or the eternal wisdom, in another hand; while a third and fourth hand giving encouragement and protection to those, who get disheartened at the immensity of wisdom they have to acquire. In one hand of Vishnu, they put the disc Sudarsana, which is always in motion, to strike down any force or power, which rises against the cosmic routine of things, for the preservation of which he is the custodian; in the second hand he has a Mace, depicting the latent power of energy and strength; while the third and fourth hand give encouragement and protection to the mind that falters. Likewise the two hands of the goddess, Saraswati, are employed in holding and playing the Vina, with sweet melodious music, to draw the attention of the people to the book of wisdom and in the third hand, a white lotus in the fourth indicating beauty and beatitude,

The hands with their weapons, sometimes take a secondary part in depicting the idea represented by the image. Look at the Fig 9. of "Durga slaying Mahishasura." Here the various hands with respective weapons take no part in slaying the demon. By looking at the buffalo the demon, it will be seen that he is not slain though his repentant spirit has left his body. The buffalo is alive, no weapon cuts his throat, he is not even wounded to such an extent as to make him fall on the side. But his activities are curbed by the pressure exerted by the goddess with her feet. The expression on the face of the goddess does not betray anger, passion, vengeance or similar feelings, which produce slaughter, but the quite and calm face, with practically closed eyes reveals the whole truth of the picture, or the allegory in the story. Here Durga represents the divine influence of goodness in the world, and the buffalo, Mahisha, represents the wickedness or the Satan. It is impossible for even God to eradicate evil from the world, so no drastic step has been taken, such as cutting the throat of Mahisha. But the evil influence is kept under control by slight pressure exerted by the feet of Durga. Her one hand is resting or caressing the head of a dwarf figure which is the departing spirit of the demon. This tells another story :—the repentant soul is sure to find protection at the hand of the Divine.

Art and craft had hardly been a profession in India; it had been a pursuit and tradition. The Silpis imparted their tradition to their descendants, and they in succession to theirs. Hindu craft organisation or caste is often termed as Guilds. Guild is an association of men belonging to the same profession formed for mutual aid and protection. But the Hindu Silpi had no enemies, to be protected from; in fact he was a much sought out

person as long as there was culture and patronage in the land. He had no competition to be afraid of, for in his days no articles of craftsmanship had been imported into the country. No weaver gave up his profession to become a stone carver. No soldier gave up his calling, unless he had a special aptitude for carving. Though major part of the tradition was maintained by caste, through gifted sons or grandsons, those who were outside the Silpi caste were not prevented from pursuing the Art. In every age there had been promoters and followers of the Art, even potentates and kings often laid down the sceptre and took up the trowel. Hence the names of even many a Brahmin are seen among the Silpis and Architects. The Architect, who built the capital of Seniya Bembisara (519-491 B.C.) of Hariyanka family at Rajagriha, was a Brahmin named Maha Govinda. The Architect, who laid out the city of Jaipur, was a Brahmin named Vidyadhar Bhattacharyya, from Bengal. According to Hieun Tsang, the sculptor of the full size image of Buddha, at the temple of Maha Bodhi, at Gaya, was a Saivite Brahmin.

Incidently instances like the latter should make one wonder whether there was a Buddhist Art and Sculpture, in India, different from the Hindu. If Asoka and his father had invited Greecian Sculptors to India, they must have gone away after finishing the work which they were sent for, probably leaving little mark on Hindu Silpis. In fact if we are to rely on historic records, Asoka's father Bindusara purchased only wine, figs and philosophers from Seleukos Nikator; but no artists or sculptors are mentioued. Some western writers and their Indian followers, appear to think that Buddhism had brought out an impetus to Hindu Art and Craft. But, as it was stated before though Buddha lived in the 7th century B.C. his images were not made before

the first century A.D. Buddha was an ascetic, he did not encourage Art or Craft; if anything his teaching had done, it was to discourage them. The Hindu Silpis did not make the images of Buddha until his real features and characteristics were forgotten, and until he began to be considered as a great sage of miraculous powers, and an Avatar or reincarnation of Vishnu. Then what about the Stupas ?

Was the Stupa of Buddhist origin ? When Tathagatha was asked what should be the shape of the Master's Tumuli, he is said to have up-turned his beggar-bowl, and indicated the shape. In any way the remaining Stupa at Saranath (Figure 10) has little of a beggar-bowl. It looks more like an enormous "Pinda" in two tiers. Pinda is a rice ball which is used in performing the Sraidha ceremony of a dead relative. When the dead is a male, the Pinda is in the same proportion as the top portion of this Stupa. But in case of a female relative, it is in a semi-spherical form like the famous Stupa at Sanchi. Shraidha ceremony, is known, in the south as Bali (sacrifice) a word pregnant with prehistoric significance, probably Shrardha ceremony was performed in older days by sacrificing animals. However from the question raised by the desciples of Buddha as to what should be the shape of His Tumuli, it is evident that some kind of Tumuli was in vouge in those days. Before the days of the Buddha, it is accepted now, that there were Stupas constructed by the Jains, in honour of their departed Gurus (teachers). Who were the Jains ? Though attempts have been made to separate the Jains from the Hindus, even today they remain submerged among the Hindus. It is admitted that there is some distinctive features about the religious life and practice of the Jains, but such differences are not in any way more distinct than those that exist among the Saivite and Vaishnavite

Hindus. No distinction there is between a Jain and a Hindu in the market place, nor in social contact. The great Chandra-Gupta was a Jain, but he is not paraded as such, like his grandson Asoka who was acclaimed as a great Buddhist. It is therefore more than probable that the Stupa was a kind of cinotaph common to the Hindus, Jains and Buddhists alike.

The shape and features of the stupas show a distinctive Vedic origin. The chief architectural features of the Stupa may be seen from Fig. (11) : Stupa (3) at Sanchi and they are:—

(a) Anda: a semi-spherical top.
(b) Harmika: a kiosk or open pavillion over the Anda.
(c) Medhi: a lofty terrace at the base of the Anda.
(d) Vedhika: a railing round medhi.
(e) Thorana: decoration at the gates.

That portion of the Stupa, which is called Anda is a solid hemisphere raised up on a solid circular base, sometimes with a centre shaft, probably introduced for constructional purpose at the beginning, but which became later on the repository of what is called relic casket. The shaft appears to have been sealed up often without the relic but always with some coins and other objects, which the Silpis are accustomed to place at the ceremony of laying the foundation and at different stages in the course of construction. It is no wonder that the archaeologist did not find in many Stupas any remains of Buddha, whose body had been burnt to ashes at the time of his death. The hemisphere may be one of the first attempts of the Silpis at solid geometry. It should be remembered that they practised the construction, with brick and motar of Ahivanya or circular altar equal in area to the square Grahapathya altar, and they practiced again the construction of Semicircular altar, equal in area to the circular and square altars. Of

course that was in a horizontal plane, and as such it was a problem in plane geometry. The next step from the plane geometry was naturally to spherical and solid geometry, the construction of a hemi-sphere on a circular base. It is more than probable that this was the genesis of the Anda of the Stupa, the "elongation" at the base may have its history in the thickness which they gave to the Ahivanya altar, and the shaft at the centre most probably have been the pivot from which the circular periphery of the huge sphere was checked and regulated in the course of construction. In some Stupas these shafts still remain to be filled up.

It is evident that the Vedic Hindus did do sacrifice on Grahapathya, Ahivanya and Daksina altars and there is no reason to suppose that they did not do the same on Daksina in its spherical shape. The sacrifice could not have been done without a flat surface on the top of the hemisphere, as a repository for the articles offered. Probably it is this flat top that developed into Harmika. The side elevation of the Harmika indicates that it was originally a fenced-in enclosure, naturally for the safety of the sacrifier and his assistants to sit in comfort and to do the pooja or killing.

To perform the pooja and sacrifice from an elevated platform has been common among the Hindus. There are certain sacrifices like "Dig-Bali", done to propeciate the malignant spirit of the air, from a squared wooden fenced-in platform constructed on the top of a pole fixed on the ground. The access to the platform is made by a ladder and a trap door. The articles of sacrifice at the present day are confined to the fowls and oblation of imitation blood, made of termeric and lime, but the raised platform gives a suspicion as to its origin. Was it for the purpose of hiding the actual cutting of the throat

from the gaze of the on-lookers? It would have been difficult for a mother to see her son's throat being cut in "Nara-Bali" (human sacrifice), even though it was for the purpose of propitiating the gods of the air. It appears that it was for the same reason that the main sacrificial altar, known as "Valia Beli Kallu", (or the big sacrificial stone) in front of the Hindu Temple deities is made so high, and enclosed in a room of its own, as is seen in many a temple in the south. The oblations on these stones are now confined to cooked rice, ghee and flowers. These sacrificial altars have a spherical contour, though often interspersed with cornices and offsets of octagonal shape. The less complicated and simple altar stone is a hemisphere on a square plinth, and with a projected flat surface on the top. Such stones can be found scattered round in and about the Hindu temples, and on which "bali" with cooked rice is done at least during the period of "Utsava". The appearance of them would make one wonder whether the inspiration for the big Stupas like those at Sanchi has been derived from these.

Thorana is nothing exclusive to Buddhism or to the Stupa; it is a decoration at the entrance of the gate. Thorana is done by the Hindu on the least provocation of a festivity. The essentials of the Thorana can be better understood in a graphical way from its Bharata-Natya Mudra, which consists of the erection of two vertical poles, one on either side and the bunting or floral decoration across. At Sanchi, as at the Hindu temple, at Muttra the decorations on the poles and on the connecting beams took the form of carving.

From these facts it may be assumed that the Stupas may not have any origin in Buddhism, and Buddha became associated with them probably centuries after his demise or Nirvana. Buddha

preached "Nirvana" or annihilation of the soul such being the theology of the Buddhism, there was nothing spiritual to be reposed in the Stupas, not even much of his physical remains, as his body had been burnt to ashes at Kusinagar, where his relations and followers gave it a right royal Hindu cremation. It might have been the Hindus, on recognising him as a great saint and a reincarnation of Vishnu, that brought Buddha to many of the Stupas by their peculiar mental conception, known as "Avaha", with attendant ceremonies and rituals. Hindus revered and worshipped the spirits of the departed ancestors, such worship was often done in front of the deposited remains picked up from the cremation ground. The creation of Buddha's image and its worship is a misnomer to Buddhism. It is Hindu in conception, Hindu in creation and Hinduism in practice.

Many Stupas were found without any bones or relics of the enlightened. In places like Sanchi there are about twenty to thirty Stupas in the vicinity, and some with no vestige of Buddha's remains. Why ? If Stupas were of Buddhist creation, any Stupa without the remains of the Enlightened has no significance. It may be probable that the majority of the Stupas were of Hindu origin. They might have been erected for the sacrifice and revered on that account. The Buddhist ascetics, in their seclusion and in their desire to be away from the maddening crowd, must have taken their residence at the Stupas. The original abode of the Buddhists was in the burial grounds with the dead body burners according to ancient Town Planning. Even now when a Fakir takes up his abode by a delapidaded tomb, his admirers and followers visit him there; the tomb is often renovated and the place becomes sacred to his followers. Similar things must have taken place in ancient

India. In this one may find a clue for the reconstruction and remodelling of some of the Stupas, some even on a grand scale.

The Hindu sculptor is idealistic and symbolical. Their ideal never has been to create a form beautiful in every respect. The Hindu Sculptor made legends of devotion, love and romance in stone, wood or any pliable material available. Their intention has never been to have factories to turn out beautiful objects for sale. When they worked they may not even have received a living wage. Still they took up the art and worked more for their ideal, than for any thing else.

The symbolism of the Silpi Art may be seen from the design of the Siva-lingam. Siva-lingam is the so-called phalic symbol of Siva. In plan it consists of three distinct geometrical figures, the circle at the top, the square at the bottom, and an octagon in the centre. The square is to represent Brahma, the octagon to represent Vishnu and the circle to represent Siva; thus Siva lingam represents all the trinities of the Hindu Mythology. From Manasara Silpi-Sastra, it will be seen that for a lingam of "Sarvato-bhadra" type the Brahma portion should be $\frac{9}{24}$ of the total height, Vishnu $\frac{8}{24}$ and Siva $\frac{7}{24}$; and for a Vardhamana type, Brahma should be $\frac{5}{16}$, Vishnu $\frac{5}{16}$ and Siva $\frac{6}{16}$ parts of the height. Other types of lingams have slightly varying proportions, but the top part in every case should be circular. The square and the circle sound like Freemasonic slogans, but the Freemasons do not pay much attention to the Octagon. Geometrically the Octagon indicates the evolutionary stage of the circle from the square. It may be mentioned here that the Stupa at Sarnath Fig. (10) looks like a magnified Siva-lingam to the uninitiated; it has a

circular portion with a hemispherical top, and the middle portion above ground has eight faces. Often the octagonal and the square portions of the Siva-lingam are or supposed to be buried in the foundation or the "Pita". Do many worshippers at the Siva-lingam realise that when they bow before the lingam, they are doing homage to all the three beings of the Hindu trinity, the "Three-Murtis", Brahma, the creator; Vishnu, the preserver and Siva, the destroyer ?

In less civilised stage man created God in his own image; in advanced stage, he made Him an impersonal God. The Siva lingam depicts a God without any form and without any features. In the delineation of the Siva-lingam, the Silpi has reached the highest conception of God, as a formless being. The worshippers at the shrine, on seeing the featureless image, is being directed to the symbol that is symbolised, the force behind the scene, the creator, the preserver and the destroyer of the universe. This highest symbolism of Iswara (God) is characterised by the vulgar as a phalic symbol, and the Siva worship is termed as the worship of the genital organ. There is as much phalic symbol in the Siva-lingam as in the circular concrete guard-posts (with spherical top) which the road engineers place at the dangerous curves of the motor-roads. However sexuality is the most remote thing in the mind of a Saivaite, when he worships before the image, and his penitent mood is further symbolised by besmearing his body with ashes. Ashes and sack-cloth have been the greatest symbol of penetancy among the human race. Despite what some western writers have said, a worshipper, before the Siva-lingam, with sexual idea, is yet to be seen. Those who see the phalic worship in Siva cult appear to have been misled by certain features. (1) The appearance of the

image. It has a remote likeness to the male organ. But closer examination will show that the Siva-lingam has none of the delienations of the male organ, such delineations which the Hindu Silpi was never shy of depicting if circumstances warranted him, if one is to judge the Silpi works elsewhere. (2) The confusion caused by the word lingam. The word lingam is used to denote sex, as Pu-lingam, masculine gender, Stri-lingam, faminine gender, Na-pumsaka-lingam, neutral gender. In that manner Siva-lingam can mean only that which is indicative of Siva. (3) The presence of a circular drain round the image of Siva, with a spout to draw off the anointed liquid away from the lingam. In this drain the perverted see the likeness of "Yoni", the female organ. Any designer would know that if a drain needs to be constructed round a circular object, it should best be circular, with a lip round it and a spout on one side as an outlet. In Silpa-Sastras this drain is not called Yoni, its name given in Manasara is "Jala-dhara" water course, which is and ought to be its correct name.

Long after the above paragraph was written I was fortunate enough to see a Siva-lingam which was in conformity with what has been stated above. It was in an insignificant village called Budhpur, on the left bank of the Kasai River, in Manbhum District of Behar, not far away from a big settlement of Santals (an aboriginal tribe who still retain their primitive simplicity of manners and customs, with a high standard of cleanliness, despite the Hindu reclamation and Christian proslytisation). Diagram (28) represents this Siva in plan and elevation. In this image the circle representing Siva, the octagon representing Vishnu, and the square representing Brahma are distinctly seen, though part of the square is under the foundation. Here as the

square forms part of the exposed lingam, the drain, the "Jaladhara" or the "Yoni" is rectangular showing the characteristic function of the Yoni as a water course and not a representation of the female organ. This Siva appears to be very old. A cursory inspection of the site will show that the ruins of the massive wrought stone masonry through which huge trees have grown, is the second temple built round the Siva-lingam.

This Siva is different from the Siva of the burial ground, with human skulls and snakes as ornaments and ashes all over the body. Neither is he who sits in Kailasa, with one wife Parvati on his lap and the second wife Ganga, on his head. Nor is he the Siva of the most intriguing love scene as depicted in Figure (12). This Siva is from Khajuraho, the deserted capital of the old Chandella kingdom, nearly half way between Allahabad and Gwaliar, where the temples of the Vaishnavites, Saivaites and Buddhists compete with one another in excellence of design and execution, probably, as Fergusson assumes, under the sway of a single prince, or in an age of extreme toleration. The appropriate title for this picture should be "An Invitation to Love". Here Siva is seen relaxed from his cosmic pose. Parvati with youth, vigour and comliness approaches him, with all allurement and confidence. She stands on her one leg, while the other folded and resting on the left lap of Siva, and her right hand round his neck. The balance is superb; the expression on the faces is apt; and the caressing hand of Siva shows response. No Kathakali dancer could have acted the scene better. Here another characteristic of the Hindu Silpi is seen, that is to make the back ground appropriate to the theme. When the god and the goddess are engaged thus, the lesser beings also follow the lead, as is evidenced from figures on the top, right and left. The original of this

is in Allahabad Municipal Museum, and it may date about eleventh century A.D.

The idealism of the Silpi may not be appreciated by foreign critics. The poets combined with the Silpis maintained the ideals and cannons of beauty. The poets lavished them on their heroes and heroines, sometimes even to an absurd limit. The poet compared the woman's breast as two perfectly shaped hemispheres closely placed to each other on the chest; her waist tapering down like a pepal leaf; her thighs like the trunk of an elephant; her face like the full-Moon; her forehead like the crescent of five nights, her gait like that of an intoxicated elephant, and so on. These ideals, the sculptors shaped in stone, and the painters rendered in colour. See Figure of the Yakshis on the gates of Sanchi, Figs. (13) and (14)

About the Yakshis on the gates of Sanchi, Rene Grousset says that "Never even in the Greece of classic age, has the innocent and spontaneous joy of life been so happily expressed. Never has the poetry of female form been rendered with a more sensuous power than in the statues of female genie (yakshinis) carved in the round, which form a link between the jambs and the end of the lower lintels of the east and north gates". The "Golden bowls" of their full bust, and all the blooming flesh of their young body sway forward into space". These figures of the yakshis may date the first or second century A. D. Compare these with the Parvati of Fig. (12) of a millennium hence.

The poet's fancy soars high without any limitation: but the flight of the Silpi is clipped by traditions and "the lineaments of the image described in books" as stated in "Sukra-Nithi. Reference has already been made to the Tala system of design.

This system fixes the dimensions of the different parts of the body in relation to height. Even the height was not arbitrary; it had to undergo a system of rigorous tests, before it was accepted; these tests are enumerated in Chapter VII. Manasara gives details of seven Tala systems. In these the heights are divided into 7, 8, 9 or 10 equal parts, it is these divisions that are known as Talas. Each Tala is again divided into 12 parts, a practice in confirmity with the Hindu reckoning on a base of 12. The different parts of the body are given in numbers or multiples of these twelve divisions. For instance in seven Tala system the face from the ending of hair of the forehead to the chin is given as 10 out of 84 parts, or the Face is 0.1190 . . . .H, when the height is H. Similarly in 8, 9 and 10 Tala systems the faces are 0.1093. . . H, 0. 1111. . H, and 0.1048. . . . H, as the length of the faces is given as 10½, 12 and 13 parts respectively. This incidently gives three types of faces according to the length alone. But there are other types of faces as well, for there is another 9 Tala system of 112 divisions, which gives the height of the face as 0.1071. . . .H; and two more 10 Tala systems, which give the respective lengths as 0.1034. . .H and 0.1014. . . . H. Similarly the breadth of the face for seven Tala system of 84 divisions is given as 7 parts, for eight Tala of 116 divisions the length as 11½ parts and so on. In like manner, the distance between each part of the body in three dimensions are given by the wise men of old, to enable the sculptor to delienate different parts thereof, according to the Sastras, but with some latitude to impress the individuality of the artist on the image of his creation. The sameness that is seen in Hindu sculpture is due to the strict adherence to these rules, incidently

the unique feature of their design also lies hidden in this. In judging outside influence, whether Persian or Greek, on Indian Art, these fundamental facts are to be taken into consideration. The Hindu tradition may be traced back to Mohenjo-daro days, and it might have been with the full use of these proportions, that the Indus Valley people managed to construct different limbs separate and then put together, like different parts of a machine. The sculpture of the Hindu is the full embodiment of his culture; it represents his devotion, his love of nature, his flights of imagination, his love, romance, dance and all put in certain mathematical proportions. He seldom created individual or personal portraits, even on occasions when he did, he attributed them the characteristics, that his ideal demanded. His poets described that his king should be an "Ajana-bahu" (one whose finger tips extending to the knees), so all his kings were Ajana-bahus. His tradition enjoined him that his saints should wear their hair in a particular fashion, so he made the coffeur of the saints in that fashion, whether or not the particular saint had any hair. He seldom imitated nature, but he gave nature what was its due.

In millenniums back he moulded the images in straw, as it is done even now by the primitive tribes in Chota Nagpur and other districts. Then he experimented with clay. His success may be judged from the Terracotta figures, Figs. 15(a), (b) and (c). Fig. 15(a) that looks like "Queen Bess" is a lady from the ruins of Kausambi; Fig 15 (b) is a gentleman from the same place; the excellence of their moulding and lavishness of the details, though worn out by centuries of decay, and impact with the plough and spade of the cultivators (for they were brought to surface in that fashion) are self evident and needs no commments. Fig. 15(c) is

perhaps that of a lady from Bitha. The samples from Kausambi are made of red clay, while the one from Bitha is of black clay, and painted over, not with red ochre and other abominations as the Hindus are doing now, but with a slightly blackish paint. The image from Bitha proclaims its relationship with Mohenjodaro in the treatment of the pupils of the eye, which appear to have been independently made and fixed, as was the nipples of breast at Mohenjo-daro. These samples were obtained, from the villagers in the neighbourhood of both the places, during an excursion, with Pandit Braj Mohan Vyas of Allahabad.

The features and details of the figures from Bitha reminds one of " the seven mothers " of the Carnatic Art of the fifteenth century A. D.; still there is no reason to suppose that the pedlers sold the models of the Carnatic art in a deserted village of a ruined Buddhist monastry, about a thousand mile away from the place of production. Our gentleman from Kausambi may remind one of the "Gandhara" art; but in simplicity and purity, he differs from the school of Gandhara. When the figure of our lady from Kausambi first came into my hand, partly covered in clay and mud, I nearly rejected it, thinking that it was a European made toy looking like the good old Queen Elizabeth; but the delineation of the lower lip, soon made me realise her relationship with the Mahesa-murti of Elephanta. Was Kausambi a meeting place of the Gandhara art of the north and Dravadian art of the south? But the historical sequence is against coming to such a conclusion.

The Silpi attainment in stone carving at its best may be seen from the Fig. (16). This image was found in Manbhum District of Bihar, at the site of an old temple, the ruins of

which have practically disappeared. The gentleman of this picture is neither a Buddha or a Bodhisatwa from Gandhara; neither does he show any relationship with the Buddhas of Anuradhapura, Ceylon. He has long lobes of ears like all the Buddhas, but he has no sandal wood paste decoration of the Vaishnavite Hindu on his forehead. His body is perfect in delineation. His hands and arms are those of an "Ajanabhahu", the ideal prince of the Silpis. His fingers are long and artistic, showing nobility, and upbringing. His face is beautiful, with a perfect nose, and a mouth that hides a smile. His headgear is not that of a Sadhu, but that of a prince of distinction. He is in a meditative mood nevertheless. Whom does he represent? I should think a prince, and a Prince among princes.

What mood of meditation is he in? It is not devotional and it is not ascetic. Does he meditate on "Sunya" or nothingness, preparatory to a revelation? No, he is not seeking anything, he is not trying to solve the mystries of nature, and he is not begging anything even at the hands of the Almighty. He stands fair and square, pure in heart and with no blemish of body. He stands like a "Man". He is alive, he is responsive and he is in perfect union with God above and man below. What "Bija" or "dhyana-mantra", (hymn of devotion) leads him on to contemplation? I would make a suggestion, and that is :—"I am standing erect. I am receiving helpful forces. I am open to all good influences. Streams of power for body and mind are flowing in. All is well". But this is no quotation from the Vedas. It is from the "Power of Will" by Frank Channing Haddock, an American. The "Prince" is individualistic enough not to efface his identity even with the Universal soul. He has found the best

in nature, as well as the best in life. He represents what is the best in Hindu Philosphy. Such an artistic representation can hardly be an imitation, not even from the masters of the ancient Greece and Mediaeval Italy. It is the soul or spirit rendered in stone. By whom? Probably by a Hindu Silpi, though one cannot be so sure of this. But it is abundantly clear that the delineation of the features is according the cannons of the Silpi Art.

This image is done in grey stone, like one of the findings from the Indus Valley, though such stones appear to be rare in the locality. This was not made as a central image for worship, for it has no "gala" or tenon, to be fixed on to a base, and its back has no finish. The roughness of the back and the lime-remains indicate that this was a wall decoration. What would have been the nature of the main image in this Temple? Time and Vandalism have obliterated it, but a few broken pieces found at the site show that it was far superior to this. Good works are rare; bad works are many; and so is the case in every country. Even in ancient Greece and in Medieaval Italy, the works of art which made them famous can be counted on fingers. Should we apply a different standard for India of the Hindus? The term India is identical with the Hindu; the Hindus are the people of India, whether they are the aborigines, Dravidians or immigrant "Aryans." Alas the term Hindu is fast disappearing. The latest term for the Hindu is "Non-Muslim", see the constitutional phraseology on the Electoral Rolls. What a traversity of fate?

"The Prince" is in a setting typical of the Hindu Silpi. When the chief image is in love, all round him are in love, when he is in meditation, all round him are in meditation. On either side

of "the Prince" there are twelve persons in similar meditation, like himself. One of them at the bottom row on the left is protected by a serpent of seven hoods, showing distinction that he is a ruler of rulers. A carving of the Bodha-Gaya rail shows distinction of rank by the number of snake head decoration like the stars on British military uniforms. In that carving king Erapat, worshipping under a tree, has a head gear with five serpent hoods like the object of his meditation, a five-hooded snake that appeared in his "dhyana" or meditation, from the body of a lake. The shades of his ancestors, who appeared in the same fashion as the five hooded god, have also varying number of serpent-hoods over their head. His father, who may not have been a great king like himself, but only a king, has three hoods on his turban, while his father's wives, two of them, have one hood each about them. See Woodcut No. 33 page 108 of History of Indian and Eastern Architecture by Fergusson. The number of serpent hoods only indicates the rank of the person, who is depicted in the carving. Hence our king with seven hooded snake should represent a Great Emperor, who followed "the Prince".

There is a bull at the feet of "the Prince". This Bull is unlike the petted and pampered bull, that one generally observes with the images of Siva; but it is in the mood of adoration, with the head uplifted. The Trithankaras of the Jains are said to be recognisable by " Chhinnas ". "Chhinna" means a sign or cognizance. Each Tirthankara, like each god of the Hindu pantheon, and each "Kutumb" (family) of the Orans, has a particular animal. The bull of Siva, though broken, and the lion of Gouri, though imperfectly carved are seen at the feet of Siva and Parvati, in Fig. (12). The totom animal of an Oran clan of

the village of Kunt, in Chotanagpur District is seen from Fig. (17). The last of the Tirthankaras, Mahavira or Vardhamana, a contemporary of Buddha, had for his cognizance a lion. One of the earliest, or the first Thrithankara Adinatha had his cognizance in a bull. Judging from this, "the Prince" represents Adinatha, meaning the original or the first leader of the Jains. But the term Adinatha (first-lord) may not indicate anything in particular, just like the places of his birth and death, as given by the Jains. His birth place is given as Vinithanagari meaning a polite town, and his place of death is given as Ashtapada, eight steps. The ashta-pada looks like a Hindu conception of Nirvana or salvation, for it is stated that by climbing up six steps and reaching on to the seventh, the feet of Siva, could be seen, and so the eighth step may indicate the final step on which the striving soul make its indentity with the Divine Soul. Speaking about the Jain style, Fergusson states that it is "always singularly chaste and singularly elegant" and essentially Hindu and doubtless common to all Hindu sects in western India". But why is it only in western India?

The Silpi traditions have not departed from the soil of its origin. The lingering practices still continue, see Figures (18) and (19). Fig. (18) represents the image of a Buddha done by a young boy of 12 years during his hobby hours in a Public School under the direction of his teacher. He had not heard of Sukra, nor anything about the canons of the Silpi Art. But he has made a Buddha, which confirms generally to the Sipli tradition. The figure is incomplete and unfinished. As it was his first attempt at marble carving, and was unused to the hammer and chisel, the neck was broken and so an ear. Here Buddha's hair is done in a conventional form, though with an imperceptible top

knot; but it is not like that of the Buddha of Gandhara. It has not the usual Hindu caste mark of Sandal wood paste on the forehead, which is invariably seen on Buddhas and Bodhisatvas of Gandhara. The young artist has shown great skill in shaping the mouth and lineaments of the face, the muscles of which show life and refinement of a high order.

Fig (19) represents Sukra the great sage who was an authority on Silpa-Sastra. It has been made in the usual traditional form of the Silpis. It was made by an "Acari" or carpenter from Travancore. His family had been famous for wood carving for generations. But this figure shows certain defects which are mainly due to lack of practice. Artists like him have no chance in the present day Travancore. Due to Christian influence Art practically disappeared from Travancore, though a revival is on foot in recent years; but such revival has not reached the realm of carving.

CHAPTER XIII

The Silpis

THE WORD SILPI IS OFTEN TRANSLATED AS ARCHITECT OR sculptor. This does not do justice to the Silpis. The term Silpi is as comprehensive as the Silpa-Sastra ; and both have a coeval existence. It is said in Manasara "the Science of Silpa, ennunciated by the great sages beginning with Him, who carries the Ganges on his head, has been elaborated by the sage Mansara, having made the subject matter even more than complete ". The one who carries the Ganges on the head is Siva, so the Science of Silpa begins with the God Siva. Manasara further states " He (Siva), as the great architect of the Universe, is proclaimed by God himself. It is He, as the architect of the Universe, Creates the world again ." " This Visvakarma (the Creator of the Universe) is born with four faces ." His eastern face is known as Visvabhu (Primordial Matter), the southern face is known as Visvavit (Eternal Intelligence), while the Northern and Western faces are known respectively as Visva-sta (State of Being) and Visva-srasta (the Creator) From these four faces four architects are born namely Visva-Karma (the Architect of the Universe) from the east face, Maya from the south face, Manu from the west face and Tvashtar from the north face. From these architects four groups or classes of architects came to be. From the union of Visva-Karma with the daughter of

Indra, the Stapathi group came; the union of Maya with a daughter of Surendra, the Sutragrahi class came; from the union of Manu with a daughter of Nala, the Takshaka class came; and from the union of Tvashtar with the daughter of Vaisravana, the Vardhaki class came. The order of importance and the qualification of the respective classes are as follows:—

I. *Stapathi*: He should be proficient in all the Sastras and Vedas, in other words his study should cover all the fields of knowledge. He should be endowed with all the qualifications of an Acharya, a guru or preceptor. He must be capable of directing, and under his direction all the other classes of Silpis should work.

II. *Sutragrahi*: He should be well-versed in all the Sastras and the Vedas, and he should be an expert in drawing and design. The word Sutra-grahi is often interpreted literally as one who holds the string or the measuring tape; this is absurd, for holding the string only a labourer is needed, but not an expert in the Vedas and Sastras or Sciences unless the Sutra here is meant the secret of things.

II. *Vardhaki*: He should know the Vedic literature; should be well-versed in the science of measurement. The measurement here will mean the selection and judging of proper measures and dimensions for respective works as well as the design and construction. He should be an expert in painting and capable of judging.

IV. *Thakshaka*: He should study the Vedas (probably Sastras as well). He should know his work; and he

should be sociable, faithful and kind in nature. He is so called because of his work. His work is stated by some as carpentry; but surely it is a wrong interpretation, for, his work includes all that involve skill and labour such as carpentry, masonry, sculpture, ironmongery, painting, etc. in which form and regularity is to be given to shapeless mass.

Manushyalaya-Chandrika states:—The Stapathi, in addition to being the knower of all Sastras, should be an adept in the proper application of the knowledge derived from them; and in addition he should have a keen intellect and adaptable mind; and he should be truthful and bear no enmity towards any one. As to the Sutragrahi, he should supervise all the work of other Silpis, and see that everything is carried out according to the instructions of the Stapathi.

Here the four classes of the Silpis and their respective attainment and duties, more or less coincide with the four classes of Masons, in Freemasonry and their respective functions. Is there then a link between the Western Freemasonry and the Hindu Silpi " Craft "?

In both there is a great architect of the universe. Among the Silpis he is the God Siva. Siva is a Dravidian God, the worship of him can be traced back to Mohenjo-daro, of fourth millennium B. C. Sir John Marshall says that "side by side with earth or mother goddess, there appears to be at Mohenjo-daro a male god who is recognisable at once as a prototype of the historic Siva." Indus Valley seals show three faces of Siva, the fourth is probably hidden at the back of the head. It was from the four faces of Siva that four classes of the Silpis descended. From the qualifications of the Silpis, it is evident that these are not four

castes, but distinctions according to the attainments. The ancestral names that connect the Silpis with Siva are all Puranic names, but their historical sequence is shrouded more or less in myth. Visvakarma now is accepted as the god of architecture. Indra is a Rig-Vedic God, who on the side of the Vedic people fought against Vritra, a great Brahmin demon, and restored rain to the parched earth. This was long before he began to be ridiculed as an intriguer in many a love affair. He is practically not worshipped now as a god except perhaps by some aboriginal tribes of Behar. Surendra or Sura-Indra must be the same god as Indra, after his adoption by the civilised community of the Aryans or Suras. Vaisravana is the god of wealth, and the guardian deity of the North. Manu is a most elusive personage, he is the first King, he is the ancestor of many a royal family, both Aryan and Non-Aryan. He is often mistaken as the Law-giver, whose code Manusmriti is applied even now by the Honourable Judges of the High Courts in deciding law suits among the contending Hindu parties, a privilege probably they never enjoyed before. Manu marrying a daughter of Nala complicated matters. If Nala, mentioned here is the same Nala, who was once the king of Ayodhya, he must have lived some 900 to 1,000 years after Manu; but if this Nala is of Nala-Damayanti story, some 130 years should be added to the difference. Therefore none of these Nalas can be taken as the ancestor of the Silpis. The other two names referred in the Silpi ancestry are Maya and Tvashtar. Maya is a great authority on Silpa-Sastra, and as such he is quoted even now in the South, and the work in his name is known as Maya Mata. With the exception of Maya, Tvashtar is the only name that can be traced in Puranic Chronology. He is a son of the great Sukra,

another great authority on Silpa-Sastra, therefore he must have lived at the early part of the third millennium B. C. He had a son called Visvakarma. If it was this Visvakarman, who came to be known as Visvakarma of the Silpi ancestry, and as the father and son being descended from Sukra, it can be assumed that the Silpi Craft has its origin in the name of the great Masters of the Art. In western Freemasonry a similar importance is given to king Solomon. Incidentally by tracing the Silpi ancestry to Tvashtar, it will be apparent that the Silpism as a Craft could not have existed much earlier than 2,000 B. C. As the temple of the king Solomon was completed in 1,004 B. C., his Freemasonry must have at least existed during the last decades of the second millennium B. C. It is very tempting to investigate whether there was any relation or anything common between these two institutions.

Both the Greeks and the Hebrews appear to have been great admirers and imbibers of the Babylonian art and culture. About the Hebrews or the Jews, H. W. Van Loon says as follows :—

"The Jews, in the beginning essentially a pastoral people without any traditions of an art of their own could not help falling under the influence of these Babylonians in whose city they had spent so many years of their lives as captives, and whose art was far superior to anything they themselves were able to develop. Even after they had founded a kingdom of their own the Babylonian influence prevailed, and as a result the famous temple of king Solomon was really a copy of an old Chaldean model." In the light of this fact, is it too much to assume that king Solomon took Freemasonry also from Babylonia? If it is not, it only

remains to be seen whether there was Freemasonry in Babylonia, and whether the Indian Freemasonry or the Silpi Craft had penetrated to Babylon? The Babylonia referred to here is the later Babylon that "for no reason suddenly rose from its ashes" and "these later Babylonians," to quote Van Loon again, "infinitely more civilized than their Assyrian predecessors or their own ancestors," turned their capital into a mighty centre of learning and science. They laid the foundations of mathematics and astronomy which so fascinated the Greeks who referred to Babylon as the "Mother of all Wisdom" and borrowed freely from their Babylonian teachers when they themselves began to take an interest in such things. In such an upheaval of science, mathematics and astronomy is it improbable that the Indian Silpis and mathematicians filtered into Babylon? The Silpis who built Mohenjo-daro and Harappa, or their descendants were not very far away from them; and the communication between the Indus Valley and Babylon is now an established fact at any rate as late as 3,500 B. C. Then again who were these more civilized Babylonians? Were they not the descendants of those barbarians from Iran or somewhere in the North, who established the Kassite dynasty of Babylon about 1750 B. C.? Could it not be possible that these barbarians from Persia carried the Silpi-Craft and science with them which gave rise to such upheaval of science and learning in Babylonia? However it might be, the similarity between the Masonic tools and Silpi tools is most striking.

The Masonic scale is divided into 24 divisions, so is the Silpi scale, the Kol. The English foot-rule is also divided into 24 divisions. The equivalent of the Silpi measure Angula is three fourths of an English Inch, or the

English Inch is 1.333333 of an Angula. If the Angula measures 1, 2, 3, 4, 5, 6, etc. were considered unsuited for setting out fine work, the most natural thing would have been to take a measure of 1.333333 Angula of a never ending nature. Most probably this was the beginning of the inch measure, though its significance has long been forgotten. The English appear to have followed a similar procedure in determining the Acre as their land-measure. Col. J. W. S. Sewell has traced the origin of Acre to Maltese Weiba, a land measure, which was introduced by Maltese miners, who came to England to work in the tin mines of Cornwall in the wake of the Phoenicians. He has also shown that Weiba is equal to $\frac{9}{10}$ of an Acre, or an Acre is equal to $\frac{10}{9}$ Weiba, or $(1+\frac{1}{9})$ Weiba. The Hindu Silpis as is shown in Chapter VII added $\frac{1}{9}$ of a Kol to itself in making their Vyaya measuring-rod. If the Hindu Silpis had not made this device in the third millennium B. C. it could have been possible to say that the Indian borrowed from the English. The Weiba is linked with the rest of the Maltese surface measure thus, as stated before :—

1 Salma = 4 Weiba = 8 Palmi = 16 Tumoli = 16 x 256 canne. Plotting this on a squared paper as in diagram (29) making canne as the smallest square, it will be seen that this is fundamentally a Silpi system of division, referred in Chapter III. Here the biggest square Salmi is divided into four Weiba squares of equal dimensions, each of which in turn is divided into four equal Tumoli squares and so on until the side of the Weiba is divided into 32 equal parts and a Weiba is made into 1024 Canne squares. The Maltese system has its parallel in the squaring practice of the Hindus (vide Chapter III). The Maltese system and the corresponding Hindu system are as follows :—

Hindu	*Maltese*	*No. of Squares*
Sakala	Salma	$1 \times 1 = 1.$
Pecheka	Weiba	$2 \times 2 = 4.$
Maha-pitha	Tumoli	$4 \times 4 = 16.$
Chanditha	—	$8 \times 8 = 64.$
Padmagarbha	—	$16 \times 16 = 256.$
Chandrakanta	—	$32 \times 32 = 1024$
	Canne.	$64 \times 64 = 4096.$

From the relation between Weiba and Acre on the one hand and the Angula and the Inch on other certain significant relationship between the Maltese, English and the Indian measurements can be established :—

(i) $1\frac{1}{9}$ Weiba = 1 Acre. $= 4840$ Sq. yards.

Therefore 1 Weiba $= 484 \times 9$ Sq. yards.

$= 22 \times 3 \times 22 \times 3$ sq. yards.

$= 4356$ Sq. yards.

$= 66$ Yards Squares.

(ii) $\frac{3}{4}$ Inch $= 1$ Angula.

Therefore 1 Yard $= 48$ Angulas.

$= 2$ Kols.

(iii) 1 Weiba $= 4 \times 256$ Canne.

$= 32 \times 32$ Canne.

$= 32$ Canne Square.

Therefore side measure of one Canne or cannom (Tamil)

$$= \frac{132}{32} \text{ Kols.}$$

$$= 4\tfrac{1}{8} \text{ Kols} = 4 \text{ Kols } 3 \text{ Angulas}$$

From (ii) it is as plain as daylight that the English Yard and the Indian Gaja of 2 Kols is the same, or the English Yard is equal to twice the Silpi Kol, a fact which appears to have con-

tributed a great deal to the sale of English cloths in the Indian market with ease, and purchase of the same with confidence; whereas the weights and measures of the seller differ from those of the purchaser there is always a great deal of doubt and distrust. From (i). It is seen that though the English Silpis took 1 and $\frac{1}{9}$ of Weiba for their acre, they did not change the internal constitution of the Weiba measure for they added only $\frac{1}{9}$ of 4356 square yards in a Weiba to itself; in other words they did not make the square root of 4840 square yards to fit in with the sides of the acre; for 4840 is not a perfect square, as its square root being 69.57........Though they made an attempt to divide the Acre into so many squares, they stopped after the first step, after having made an Acre into four Roods; if they had attempted any further they would have had to face unpleasant surds 5 and 11. From (iii) it is seen that the Maltese or some body else added 3 Angulas or $\frac{1}{8}$ Kol to 4 Kols to make it a Canne (linear). It reveals the previous struggle they had in finding suitable measures for divisions. Four Kols they divided into 32 divisions and then added $\frac{1}{32}$ Kol more to make the measure flexible. Again the Maltese in adopting four Kols as the basis for their Canne, they appear to have taken the double of another Hindu measure, Danda, of 192 Angulas. The Danda measure they used "in measuring such lands as are gifted to Brahmans" at any rate in the 4th century B. C. according to Kautilya's Arthasastra.

It may be possible that the English Silpi took the Weiba and the Yard from the Maltese and the Maltese got the same from their Hindu brethren; both the nationals being Dravidians, • such is not beyond the limits of possibility. The English Silpi then divided this linear yard into three divisions

and called each a foot just like the Hindus who divided his Kol into three and called each a Yoni. Thus it may be that the measure started by the Hindus by the hand ended in England as measure by foot. This may not have been due to any caprice on the part of the English Silpi. It should be seen that one Yoni is six inches, and one foot is twelve inches or 2 Yonis. In dividing the foot into twelve, the English Silpi knew what he was doing. He took his reformed inch which was 1.333333 of an Angula and put them on a basis of twelve for the sake of easy reckoning, for which even today his successors, the Surveyors and Civil Engineers are grateful to him, for, their duo-decimal system of easy computation is based on this reform made by their ancestors. The Hindu Silpi had also a reckoning based on base twelve, as explained in Chapter VII, but there his divisions were each equal to 3 Angulas or two and one fourth Inches.

Enough has been said to show the similarity of the English measure and the Hindu measure. Much more can be said if one wants to show that the English measure is derived from the Hindu measure or the Silpis in India and England worked on the same basis. Is this a mere coincidence ? Or the English Silpi got his measurement from the Hindu Silpi ? If the latter presumption is correct, it may be that it was the Freemasons who took the Hindu measure to England.

Was their route from India to Malta and thence to England ? Or was it from India to Babylon, Babylon to Palestine, and Palestine to Scotland ? It appears that the latter route was more probable, for, after the destruction of the Second Temple in 70 A.D. by Titus, a group of Masonic emigrants left the Holy Land in

great grief and appeared to have settled down in Scotland, where they established the Ancient Lodge at Killwining.

The Silpis undoubtedly occupied a very high position in India. From Manasara it is seen that the study and applications of the Vedas was one of their primary qualifications at one time. But the author of the Manushyalaya-Chandrika completely left out the Vedas as a subject for their study. This is not merely an omission; for the Silpis by this time had fallen from their once high position, probably the low position in which they are found in some parts of India today. In Travancore the Silpis, though they still hold the proud name of Acari, or Acharya (preceptor), they are unapproachables to the high class Brahmans and untouchables to the Nairs. The cause of this degradation is very difficult to explain, yet, it can be safely said that it was due to the rise of Brahmans who from a servile position assumed dictatorial powers even over the kings based on spiritual claims. The Brahmans were mere priests in early Vedic days. Later on they became so powerful that even the kings of Ayodhya had to bow before the Vasisthas. The Bhargavas, another family of priests specialised in war-fare; the famous Parasu Rama claimed to have exterminated the entire race Kashatryas, not by any spiritual powers but by force of arms. In early days the study of the Vedas was not confined to any particular class, it was common to all. Those who had a special aptitude for learning took up the study, including the Silpis who needed it most on account of their profession. An ending to this happy state of affairs appears to have come sometime at the beginning of the first millennium B. C. probably after Vyasa came to fame. He divided the Vedas into four as Rig, Yajur, Sama and Atharva, and placed each in custody of four of his disciples; to

Paila he gave the custody of the Rig, to Vaisampayana the Yajur, to Jaimini the Sama, and to Sumantu the Atharva Veda. Still there was a lot of unclassified literature. These were "the tales, anecdotes, songs and lore that had come down from the ages" and known as Puranas and Ithihasas; they were left with the Suta Romaharshana or Lomaharshana. From circumstantial evidences it is known that Vyasa lived at the latest about 1,000 B.C. for he begot through the wives of King Vicitra-virya, Pandu and Dritharashtra, whose sons were the contending parties in Maha-Bharata battle. Vyasa's attempt was not the first to classify the Vedas; several attempts before him had been made by other learned men commissioned by mighty kings of earlier days. About one hundred years before Vyasa, during the reign of king Hiranyanabha, three Vedas: Rig, Yajur, and Sama took separate and definite shapes, while Atharva Veda got separated long before the time of the great king Bharat, (the son of Dushantha) who was very keen on sacrifices and performed many. This was probably before the sixteenth century B. C. After Vyasa or Vyasa Dwayipayana, an epithet he earned on account of dividing the Vedas, the Vedas and Puranas became the prerogative of his five disciples and their descendants, who appear to have made additions and alterations of their own to establish their exclusiveness, importance, rights and privileges. Since then the rest of the Brahmans and others appear to have had little to do with the Vedas so much so that now more Europeans know about the Vedas than the Brahmans. This unfortunate state of affairs seems to have deprived the Silpis the study and use of the Vedas. The loss of the Rig Veda may not have been of much consequence to them, for it contained only invocations to various Gods, but

the loss of Yajur and Atharva became a great handicap. Because it was in these and their commentaries the technical and the theoretical side of the Silpa-Sastras were concealed. When the Silpis were left with the practical side alone of the Silpa-Sastras, they became the maintainers of an early tradition, and not the Masters of the Craft. The theory and the "Sutras" (the secrets) in the hands of the Brahmins were of no avail, for they, having had little occasion, to practice did not know in course of time their real significance. But even in the depth of their ignorance they could not be baffled, for they took the mathematical diagrams, survey sketches and such like for sorcery and necromancy, to establish their importance and to squeeze money out from the credulous public.

Even without the inner knowledge of the Silpa-Sastras, the Silpis for long have carried on, and the result of their achievement is seen throughout the length and breadth of India and in her former colonies. The marvellous records of their craft bear testimony to the perfection of their science and the zeal and devotion dedicated to the craft. Their record is unbeaten, and their fame will spread far and wide when the lost art is recovered. One cannot help wondering what would have been their achievement if the Science had not been separated from them. Where are the Silpis or their descendants now ? They are practically everywhere in India. They are submerged in the vast multitude of working men. Some of them are paid by Government contractors and Engineers to do bad work, while others eke out a living by catering for the so-called unprogressive and backward section of the public, who cannot get the services of the westernised engineers and architects. Under the western influence the taste in architecture and sculpture is

undergoing a change and the Indians are after less suited types of houses, and less imaginative and less inspiring types of sculpture and painting. The Silpis are mere artisans now; but there was a time when they were artists, artisans and scientists combined. Van Loon says that "the artisans were able to give a clear representation to the Spirit of his own time." This is so true of the Hindu Silpi. From time immemorial, they gave us the spirit of India. When the Hindus predominated they gave us the magnificient images and temples, under the Buddhists they gave the beautiful chaityas and stupas. Even under the Mohammedan rule, for the sublimity of the mosque and immambaras, the Hindu Silpi was more responsible than any one else. But unfortunately under the British rule he had not had a fair chance.

Eminent writers, both eastern and western, are making water-tight distinctions between the Hindu, Buddhist, Jain and Mohammedan architecture. Undoubtedly there had been motives showing the spirit of time in each, but they were the works of the Indian Silpi, who knew no difference between religions and races. The earliest of the Christian Churches, belonging to the Syrian Christians in India were the works of the Hindu Silpi. They no doubt introduced certain motives according to the requirements of the Christians, in the same way as they introduced Vaishnava motives in Vaishnava temples and Saiva motives in Siva temples. When these motives and decorative features are separated it will be seen that the science of architecture, the dimensions, the proportions and all are according to the Hindu traditions. The squares and octagons, which form the main feature of the Taj and Fatepur Sikri can be seen most predominantly in much earlier temples of Madras,

The Silpi architecture is condemned because the temples are unlike the Cathedrals. This is due to a lack of app.eciation of the spirit of the time, motive in design, and object in view. Due to bleak, cold and uncongenial climate all activities in a cathedral he had to be inside the closed doors. So big halls were constructed for commnnial worship, which is practically foreign to Hinduism. The high walls needed support, so lean on the sides were made, which gave more space as well. To bring in light, in an age without electric lights, high windows with glass panes, had to be constructed, and then to cover the ugliness and plainness of the glasses, colouring or staining was introduced, depicting the Biblical stories and incidents in the life history of the saints and the saviour. It may be said that the beauty of a cathedral consists in the stained glasses and the quality of high vaulting. Hardly any one goes inside the Hindu Temple, even the Poojari who does the rituals goes inside only two or three times a day. All the activities in a temple are outside the shrine. So the outside had to be made beautiful, leaving the inside with a vaulted chamber for *sanctum sanctoris*, and subsidiary vaulting to make the roof high. To the high pointed or peaked roof, the Silpi gave different geometrical shapes and forms. Often when a plain surface was available they embelished it with carving. Through such carving, they imparted the knowledge of History and tradition. The people had heard the stories from their story-tellers. The Silpi tried to depict them in stone or plaster. The carving on the temple buildings show the stories of their Puranas and Ithihasas, the deeds of their gods and great men. It is admitted that some of the figures are grotesque. But what would happen if the picture of a demon in an English story book is given the fine features delineated by

Michael Angelo? The Hindu Silpi did not spare pains at the interior decoration, where it was necessary. When he built cave temples, he showed the excellence of his art. He was a master of his craft. In the story when god Vishnu sits in his blissful abode, with the goddess Lakshmi by his side, his features are delineated with full tenderness and love. But when he kills Hiranyakasipu, the most powerful and arrogant demon, Vishnu is given the body of a man with the head of a beast, for the beastly brutality with manly stratagem was required to kill that ferocious demon. So in every feature of God, man, Yakshi or Kinnara, the Silpi showed appropriateness in the delineation compatible with the mood, temper and motive. The Silpi catered for the people, and for the times. He will do so most successfully again if he is given the chance.

CHAPTER XIV
Conclusion

HOW IS IT POSSIBLE TO WRITE A CONCLUSION TO AN INVESTIGATION which is not completed? A fringe of this vast subject has only been touched. Even main items like painting and decorative art have been left untouched. However, what little has been said here may serve as an introduction to the Silpi method and their art. In presenting them in their correct perspective, I have had no intention of lionising the Silpis or their art; praise was given only where it was due. Though we may find occassionally a correct appreciation of the Silpi art, the general impression in the country and elsewhere is not very complimentary. The Europeans in judging the art have been consistently fair, but their judgment is often handicapped by a lack of understanding, of what may be called things oriental. It is impossible for them to pry into the oriental mysteries, as it is impossible for them to appreciate the Hindu music which should be listened to by squatting on the floor. Originality appears to be the last thing which the Western writers credit the Indians with. Even imitation of bamboo basket work in stone could not, in their opinion, have originated in India, though the Indian forests are full of bamboos and even the primitive races have acquired a high proficiency in making mats and baskets. The secret

of making well balanced boats with stream lines though it is known only to a very limited number of Silpis, is stated to have been brought by the Chinese to the south-west coast of India. If one wants to see the Silpi balancing and the streamline, he should go to Travancore and see the annual boating display at Aranmula. Unfortunately the Indian writers, some of them, go to the other extreme; according to them everything has originated in India; they even see the bombs of the First World War in their old "Agneyastra," and the atomic bombs of the Second World War in the "Sudarsana" of Sri Krishna. Both are doing a disservice to the Indian Silpi. The Indian Silpi appears to be capable of standing on his own legs, despite undue adoration on one side and traducement on the other.

The mistakes, of the Western writers, are not intentional; they are genuine. When I, an Indian, for the first time saw some Hill men in Naini Tal going about with folded "Hukkas" under their arms, thought that they were some sort of musical instruments like "Bagpipes", and wrote to a friend in Scotland that the Hill tribes of India were as musical as the Scotish Highlander. If an Indian could make such a mistake about things Indian, how could one blame a European in committing similar mistakes and arriving at wrong conclusions? The Western writers judge by Western standard. Before they study the Indian Art and Architecture, they get familiar with the Ancient and Medieval Art and Architecture of Europe; and when they see things in India, they try to connect them up with things Western. It is quite natural. Still the Europeans have done tremendous service to Indian Art and Architecture, they have brought to light this long forgotten art, long forgotten in the country of its own origin. Had it not been for their works and the English language,

I would not have been able to launch on this investigation. But the apt pupil is liable to criticise even his own master.

Many a misunderstanding in this respect is due to preconceived notions such as Aryan Invasion of India, and the civilising influence that came from the West in the wake of Alexander's invasion. Have we got sufficient proof to show that there was an Aryan invasion, or a large scale incursion of a civilised race from outside? If there was one why the descendants of these invaders have not kept any tradition of their incoming? Would the self glorifying Brahmans have hesitated to record it if there was a vestige of it? Nothing of it is traceable in the whole literature of the Hindus, Vedas, Sastras, Ithihasas, Puranas, etc. If one doubts this statement, he or she is directed to Pargitter's "Ancient Indian Historical Tradition." Alexander's invasion touched only a fringe of India. Then was his invasion a civilising mission? Even his great general Ptolemy established the famous school, at Alexandria, only after he became acquainted with the East. Was he not influenced by what he saw in the East? These are the points one has to consider in details, before any foreign source is attributed to the Indian Civilization.

Max-Muller, a great Anglo-German Orientalist did meritorious service to India (though he never visited this country), by disclosing Vedic religion to the West. From the study of comparative Philology, he came to the conclusion that Sanskrit, Greek and Latin must have a common origin, and if so the ancestors of these three language-spoken people must have come from a common stock outside India. Since his days the place they came from has shifted from the Ural Mountains to Eastern Europe; and the deduction of the unity of races from the languages they spoke has been discredited. The Hindus, like

Bala Gangadhar Tilak, were very active in establishing a North or Polar regional habitation for the Hindus before they penetrated to the banks of the defunct Saraswati, in the Punjab. Though Balagangadhar Tilak, of revered name, has done meritorious service to Indian Nationalism, his attempt in this appears to be a disservice to India. The HIndu Astronomers asserted that the Polar regions have days and nights of six-months duration, from this he appears to have come to the conclusion that the ancestors of the Hindus came from the Polar regions. There is enough argument in this to conclude that the British came from the Polar regions, because they wrote about the North Pole after its discovery by Shackelton. Then the Hinduism and all the best of everything that it stands for is stated to have had its origin on the banks of the Saraswati or Brahmarsi Desa, where the climate is comparatively cold. If the Hindu rites and ceremonies were originated in Brahmarsi Desa, or where the climate was cold, the Hindus in doing their "Puja", would have been wearing some sort of cloth to protect them from cold. On the other hand all the "Pujas" are done after casting off all clothes except a loin cloth of minimum dimensions. Why, the orthodox Hindus even when they eat take off their turban, Kurta and Pyjama, and put on only a loin cloth? For, eating is a sacrament to them. This may denote that the origin of the Hinduism was in a very warm or hot climate. Does not the light surplus, worn over their warm suits by the Christian priests in the cold climate of Scotland, remind one of its origin in the warm climate of Eastern Europe or Asia minor ? Buddha of Gandhara is fully draped in cloth, while the Buddhas of the South, and the Tirthankaras are raked. The Hindu religion and worship appear to have started somewhere

in a uniformly hot climate, probably in the south of India; even the sacred thread worn by the "twice-born" appears to be a South Indian product, for it was the Dravidians who introduced, if not invented, cotton weaving; sacred thread, according to Gilbert Slater, indicates the original association of the Brahmans with cotton spinning and weaving.

India is known as a country of different cultural groups, and warring elements. As the size of India is as big as the whole of Europe except the Scandinavian peninsula, and as it contains a fifth of the population of the world, it is nothing unusual if it were so. But with all the differences that are, there is a cultural plane in which all are the same; and for a correct appreciation of which "the Way of the Silpis" may give a substantial clue. Indian Art and Architecture is divided into many groups, like Jain, Buddhist, Dravidian, Gandhara, Gupta, etc. Such divisions may serve the useful purpose of studying the cultural and artistic developments at different times, under different influences. But to consider them as different from each other will not be the right line to be taken up. There are no doubt certain differentiating elements, but they are due to local conditions and timely adjustments. All the same if they are studied with a critical mind, it will not be difficult to see that all of them have a common origin, and on the scientific plane they do not differ from one another. For such an understanding, a close study of the Silpa-Sastra appears to be most essential. Have we any other use with the study of the Silpa-Sastras? By a close study of the Vedas, Max-Muller revealed that the Hindus were not all liars. Similarly a close study of the Silpa-Sastra may reveal that our long forgotten ancestors were not all barbarians, they had a culture unique in many

respects, higher in attainment, original in conception, and not imitated from elsewhere. Further we may find something useful in them to remedy some of our ills and evils in Town-planning, House-planning and Artistic development.

India's past lies buried and long forgotten. The remains that have been unearthed have revealed her greatness. A great deal of spade-work still remains to be done. This book is the result of a little "deep-digging" in the field of the Silpa-Sastras. Though imperfect and incomplete, it is hoped that this may be of some service for a correct appreciation of the Indian Art and Architecture on scientific lines.

END

1	2		3	4		5		6	
EXTENT OF RASI	RASI NAMES		EXTENT OF NAKSHATRAS	NAMES OF NAKSHATRA		NAMES OF MONTHS		CORRESPONDING GREEK ZODIA	
	(a) TAMIL	(b) EQUIVALENT SANSKRIT		TAMIL a	EQUIVALENT SANSKRIT b	(a) TAMIL	(b) EQUIVALENT SANSKRIT	(a) SIGNS	(b) NAMES
10° 20°	META I	MESHA	13°20'	ASWATI	ASWINI	AIPASI VII	ASWAYUJA	♈	ARIES
30°			26°40'	BHARANI	BHARANI				
40°	ETAWA II	IRSHABHA	40°-0	KARTHIKA	KARTHIKA	KARTHIKAI VIII	KARTHIKA	♉	TAURUS
50° 60			53°-20	ROHINI	ROHINI				
70°	MITHUNA III	MITHUNA	66-40'	MAKAYIRAM	MRIGASIRA	MARKAZI IX	MARGASIRSHA	♊	GEMINI
80° 90°			80°-00'	ATHIRA	ARIDRA				
100°	KARKATAKA IV	KARKA	93°-20	PUNARTHAM	PURNAVASU	THAI X	POUSHA	69	CANCER
110°			106-40'	POOYAM	PUSHYAMI				
120°			120-00	AYILYAM	ASLESHA				
130 140°	CHINGA V	SIMHA	133°-02	MAKAM	MAKHA	MASI XI	MAGHA	♌	LEO
150°			146°-40'	POORAM	PUBBA				
160° 170°	KANNI VI	KANYA	163°-00'	UTTARAM	UTTARA	PANGUNI XII	PHALGUNA	♍	VIRGO
180°			173-20'	ATTAM	HASTI				
190° 200°	TULAM VII	TULA	186°-40'	CHITTIRA	CHITTA	CHITHIRAI I	CHAITRA	♎	LIBRA
210°			200°-00	CHOTHI	SWATI				
220°	VRICHIKAM VIII	VRISCHIKA	213-20'	VISAKAM	VISHAKHA	VAIKASI II	VISAKHA	♏	SCORPIO
230			226°-40'	ANIZAM	ANURADHA				
240°			240°-00'	KETTA	JYESTHA				
250° 260°	THANU IX	DHANU	253°-20'	MOOLAM	MOOLA	ANI III	JEYSTHA	♐	SAGITTARIUS
270			266°-40	POORATAM	POORVASHADA				
280 290°	MAKARAM X	MAKARA	280°-00'	UTTARATAM	UTTARASHADA	ATI IV	ASHADA	♑	CAPRICORNUS
300°			293-20	ONAM	SRAVANA				
310° 320°	KUMPAM XI	KUMBHA	306°-40'	AVITTAM	DHANISHTA	AVANI V	SRAVANA	♒	AQUARIUS
330°			320°-00'	CHATHAYAM	SATABHISHA				
340°	MINAM XII	MINA	333°-20	POORUTTATHI	POORVABHADRA	PURUTTASI VI	PPOSHTAPADA	♓	PISCES
350			346-40'	UTTIRITTATHI	UTTARABHADRA				
360°			360°-00'	REVATHI	REVATI				

TABLE 2 Showing :—(1) Derivations of tamil Months from Corresponding Nakshatra or Constellation (2) Derivations of North Indian Months from Tamil Months (3) Derivations of Sanskrit Rasis from Tamil Rasis (4) Comparision of Indian Rasis with Greek Zodiac and Egyptian Hieroglyphic

II

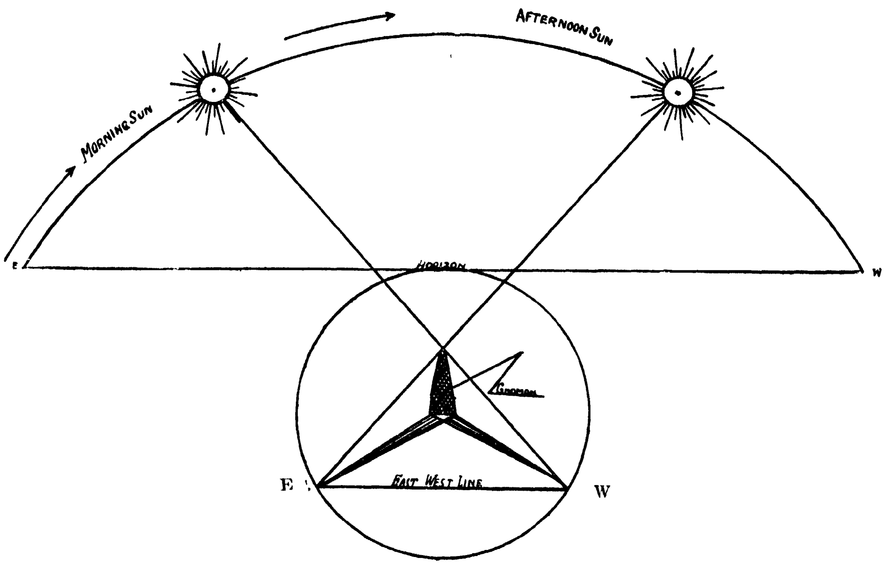


DIAGRAM 1
Fixing Fast West Line from Shadow Cast by a Gnomon
(See P. 14).

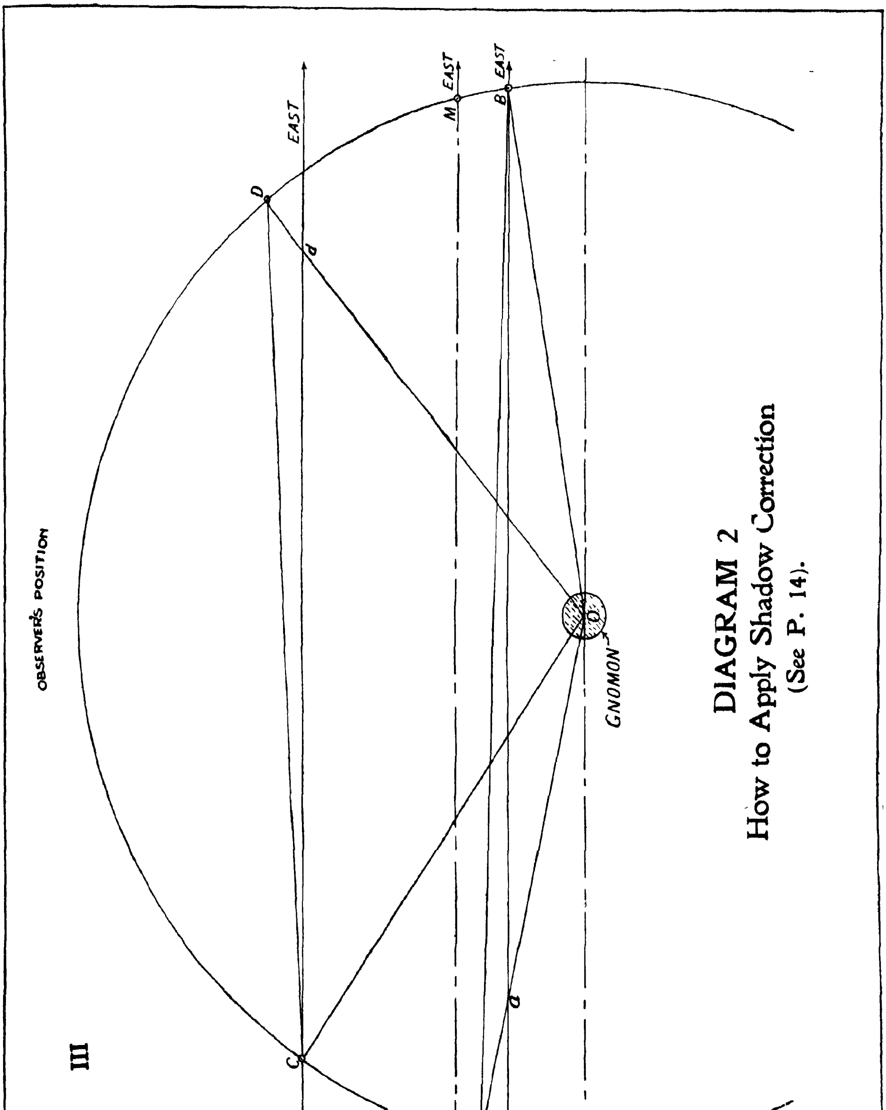


DIAGRAM 2
How to Apply Shadow Correction
(See P. 14).

DETERMINATION OF EAST AND WEST

BY OBSERVATION OF SHADOW CAST BY GNOMON OBSERVATION TAKEN AT ALLAHABAD LENSTH ON GNOMON $9\frac{1}{32}$

IV

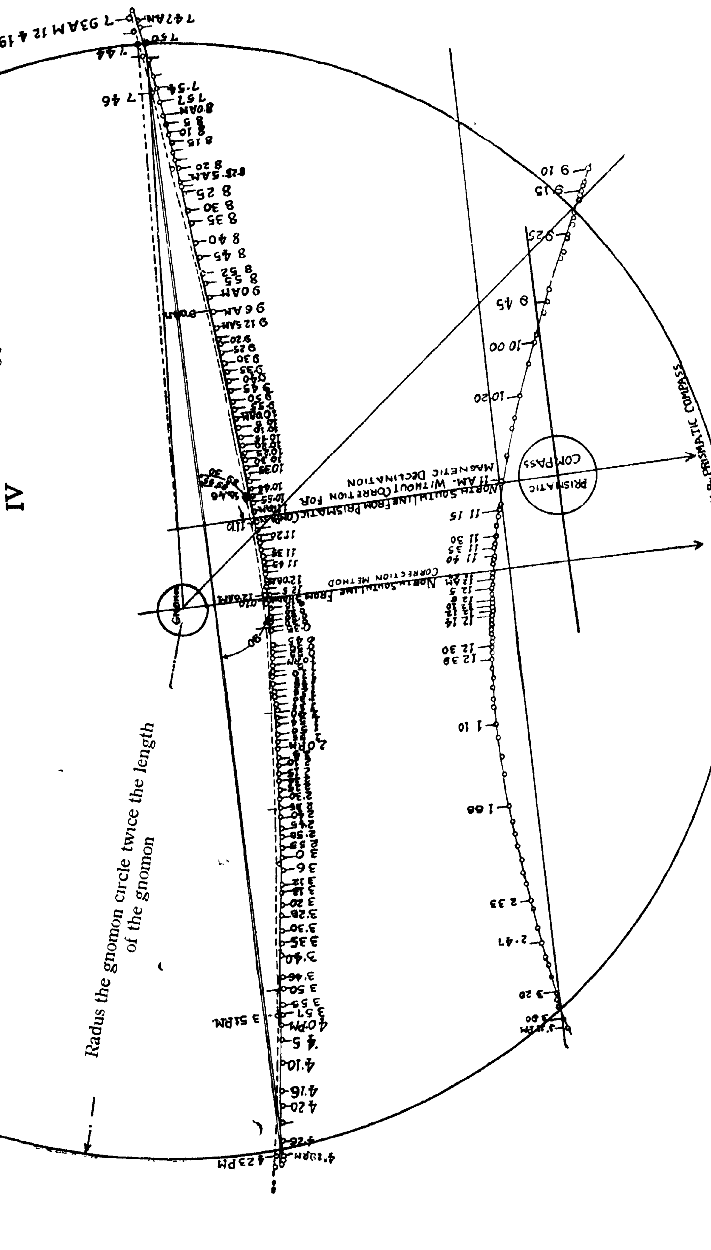


DIAGRAM 3

(See P. 15).

V

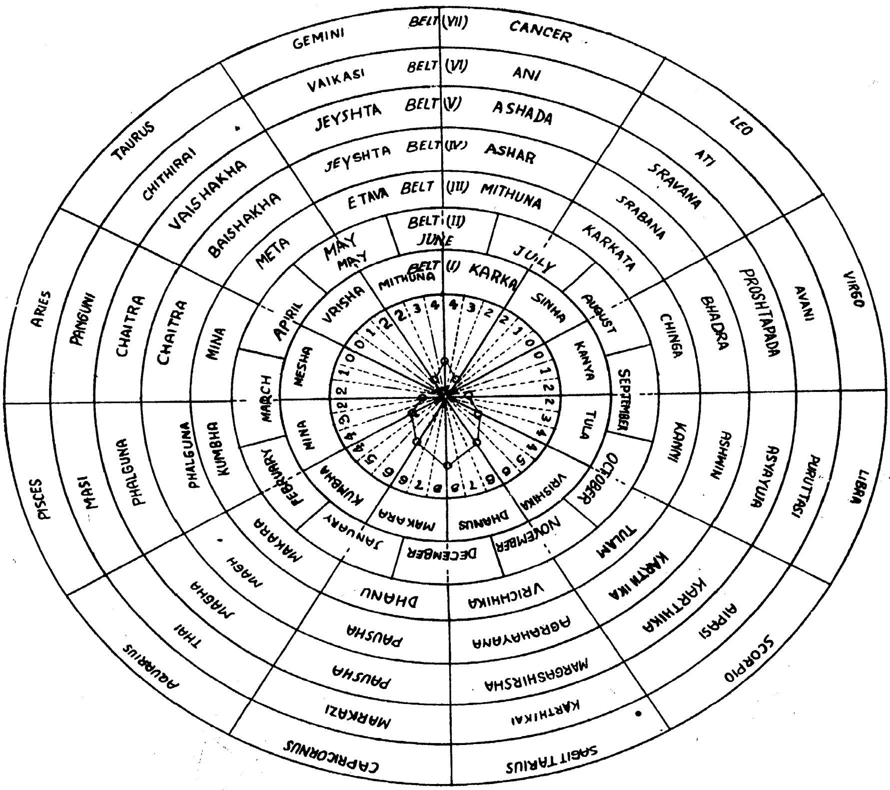


DIAGRAM 4

(See P. 21).

ZODIAC

(i) In the Inner Circle Manasara Shadow Correction Figures are given against each ten days of the month.

(ii) The tortoise-like figure in the centre is the graphic representation of the shadow Correction Figures.

(iii) Belt (i) Manasara Months Against Corresponding Shadow Correction Figures
Belt (ii) Corresponding English Months
Belt (iii) Correspondlng Malayam Months
Belt (iv) Corresponding Bengali Months
Belt (v) Corresponding North Indian Months
Belt (vi) Corresponding Tamil Months
Belt (vii) Greek Zodiac

VI

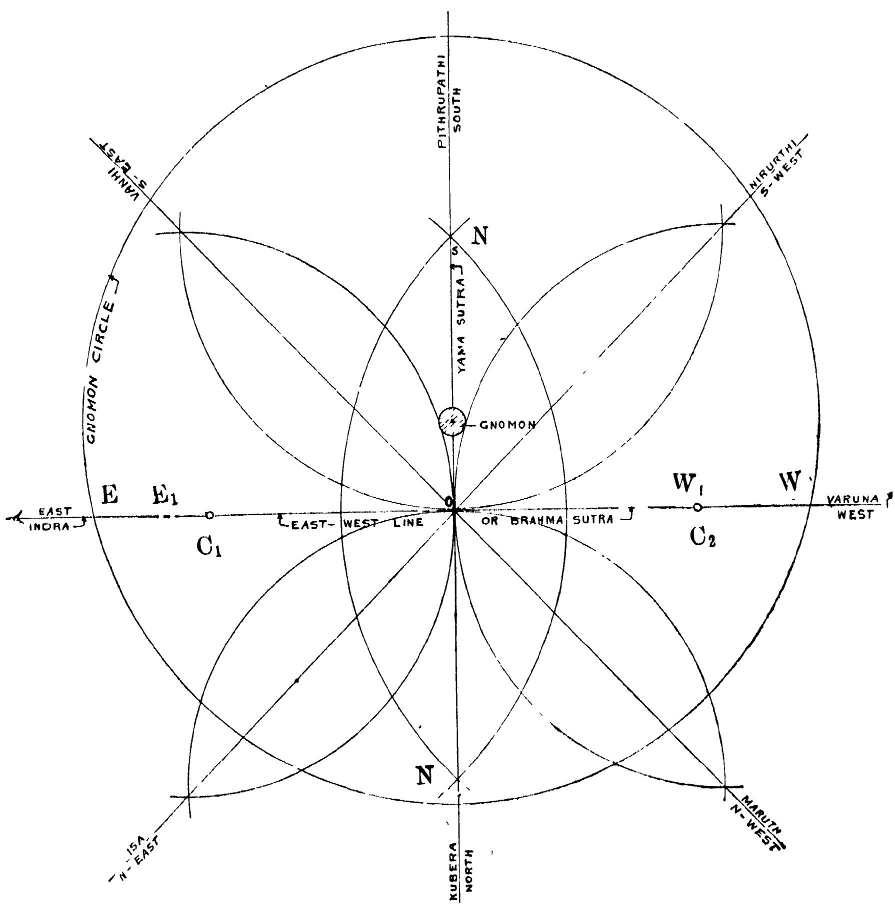


DIAGRAM 5

Geometrical construction to derive cardinal points from East-West Line

(See P. 36).

VII

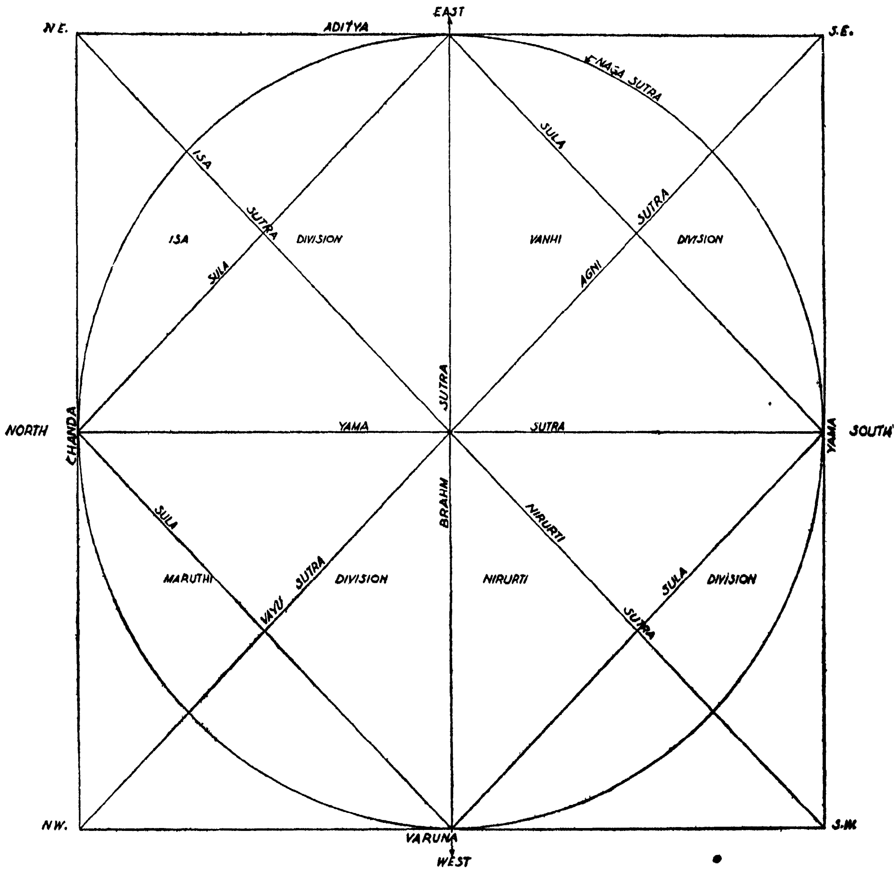


DIAGRAM 6
Sutras and Cardinal Plots

(See Page 42)

>III

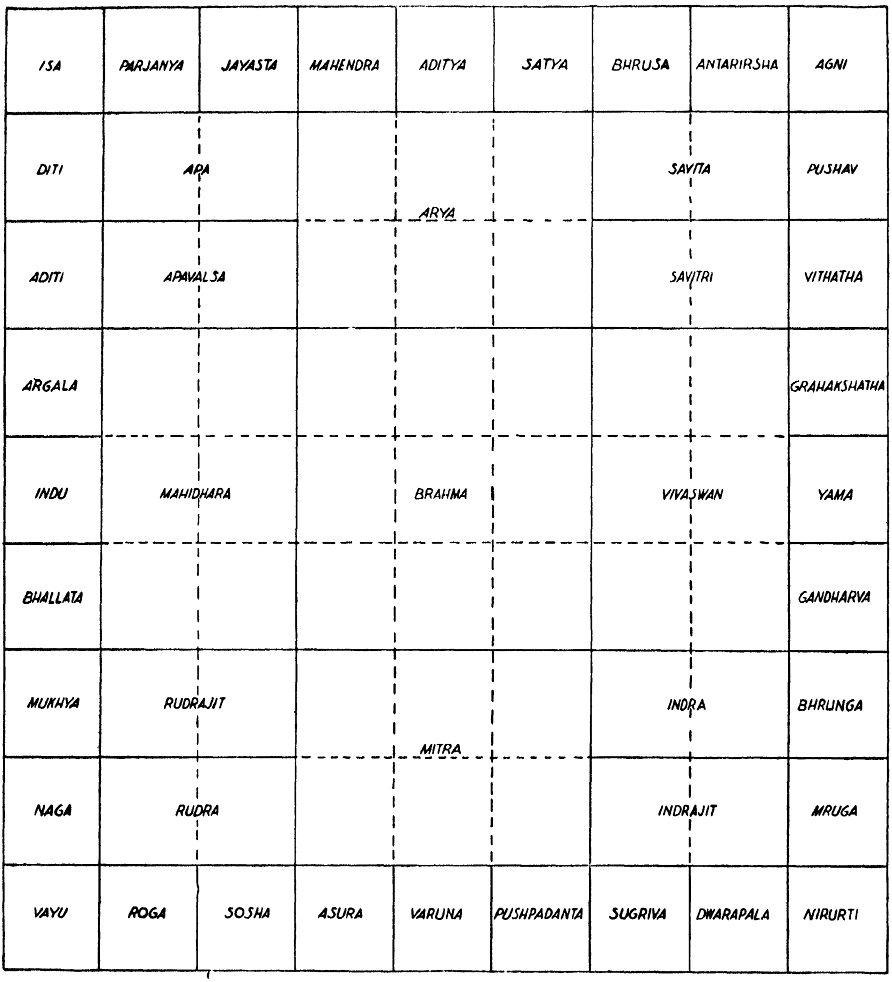


DIAGRAM 7
Parama-Sayika 81 Divisions and 45 Gods

(See P. 44).

IX

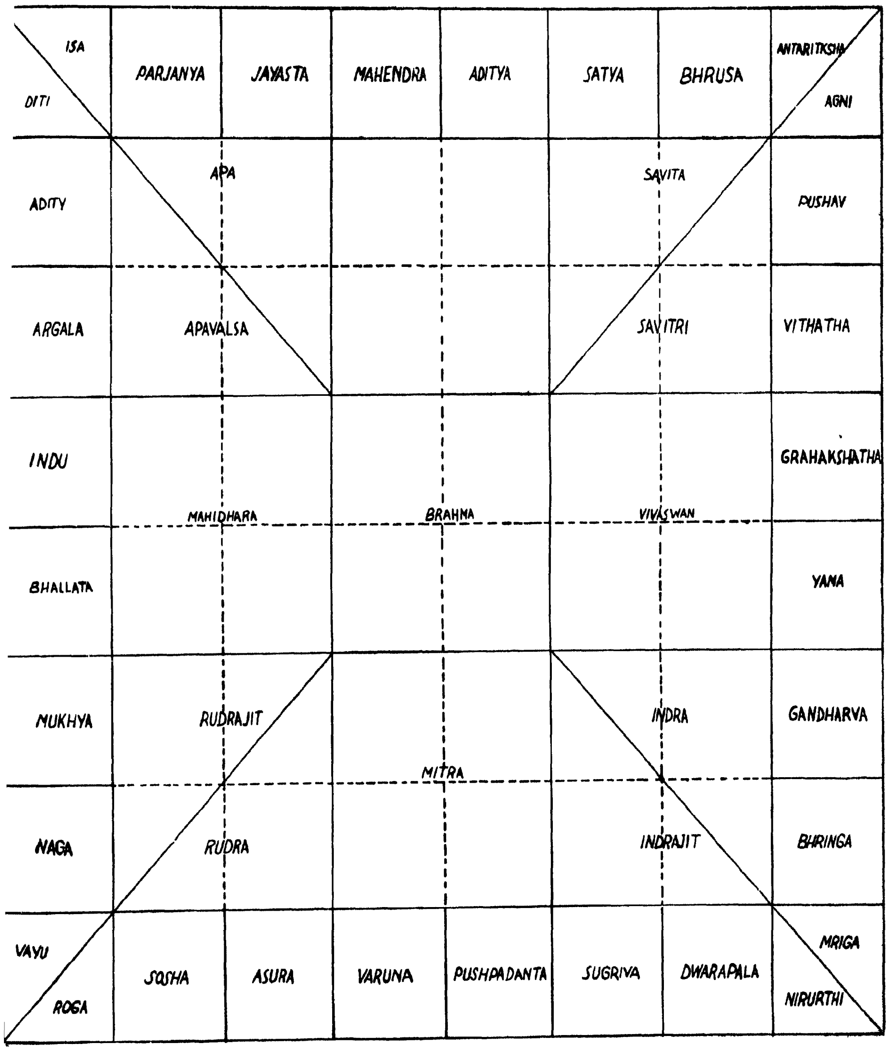


DIAGRAM 8

Chandita 64 Divisions and 45 Gods

(See P. 44).

X

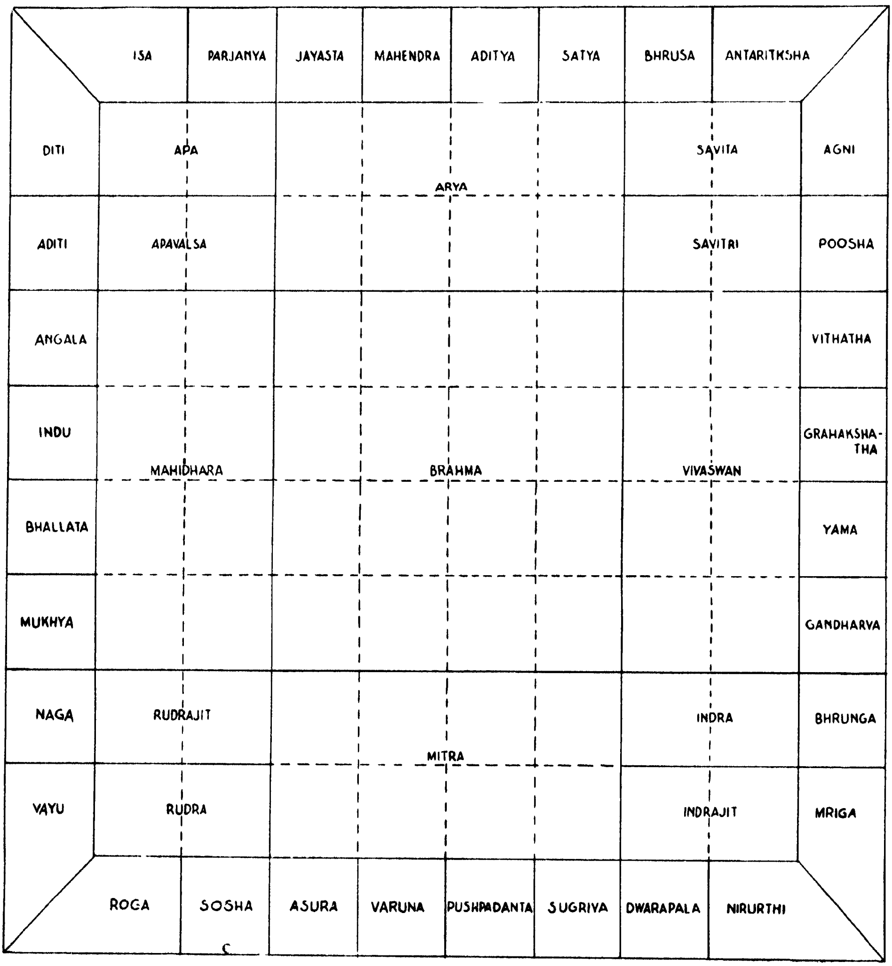


DIAGRAM 9

Asana 100 Divisions and 45 Gods

(See P. 44).

XI

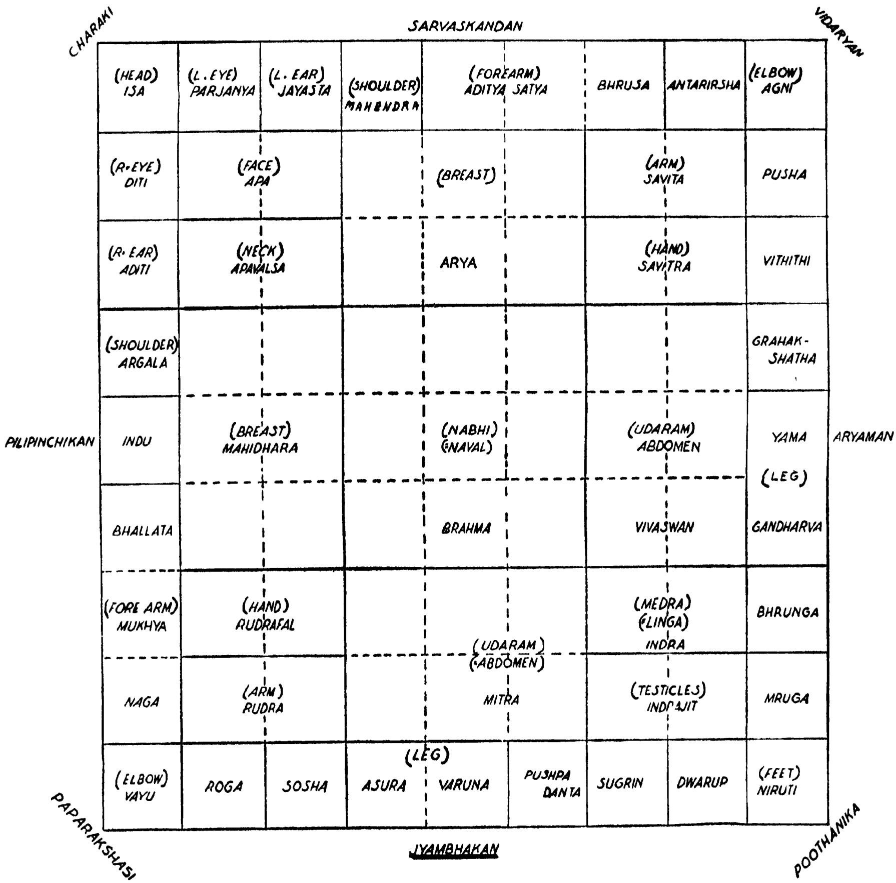
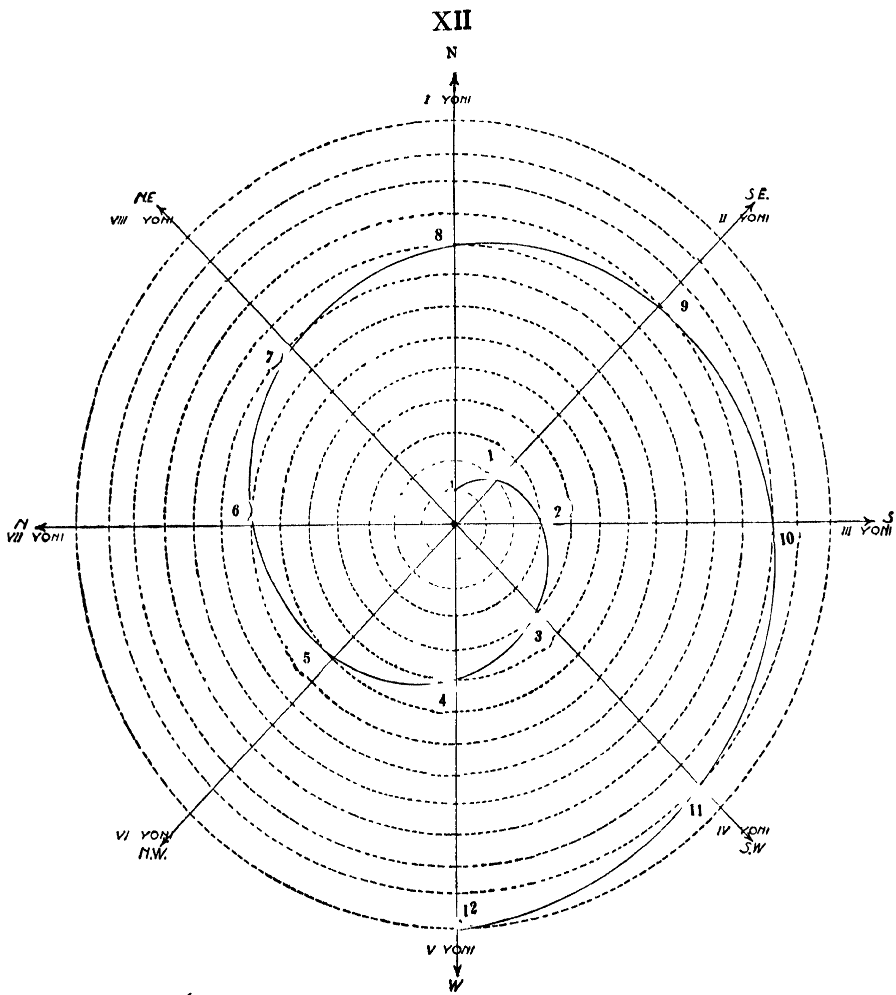


DIAGRAM 10

Vastu Rakshasa in 81 squares with Gods on the Limbs

(See P. 48).

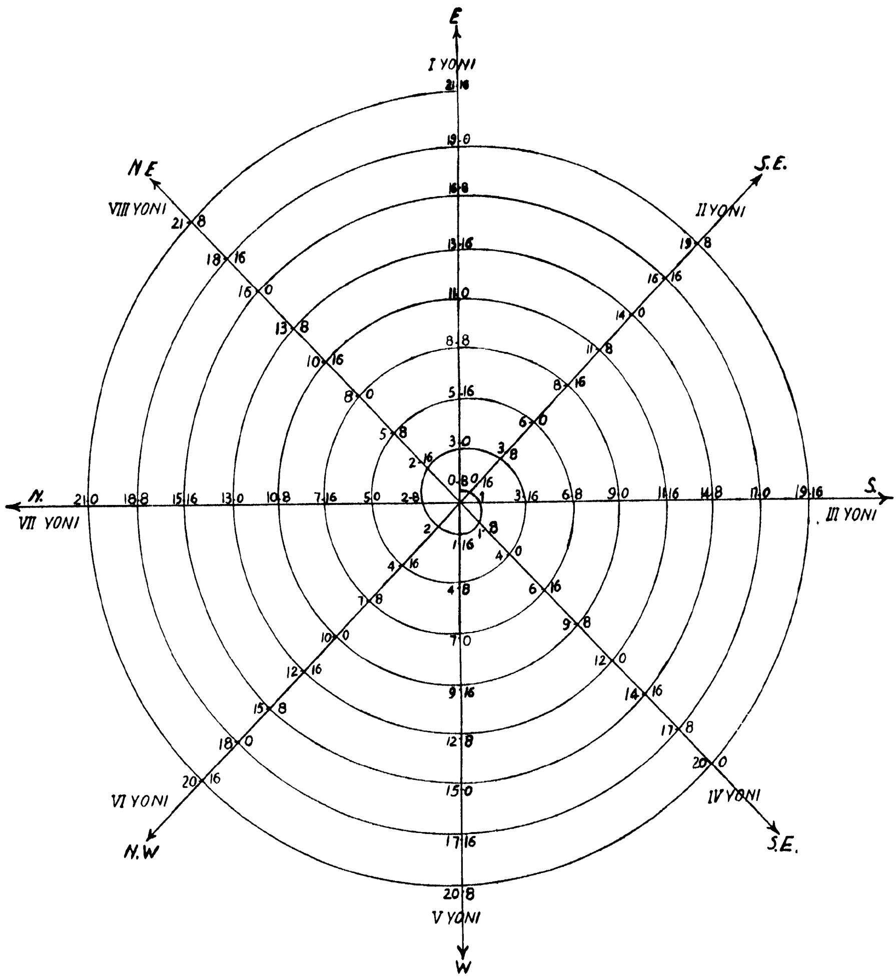


FORMATION OF YONI SPIRAL

DIAGRAM 11

(See P. 89-90).

XIII



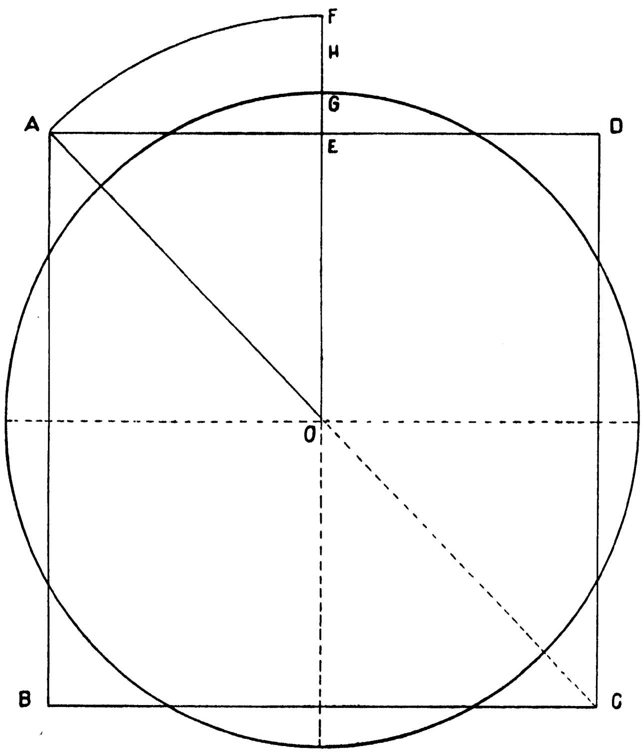
YONI SPIRAL WITH PERIMETERS

DIAGRAM 12

(See P. 90).

XIV

EAST



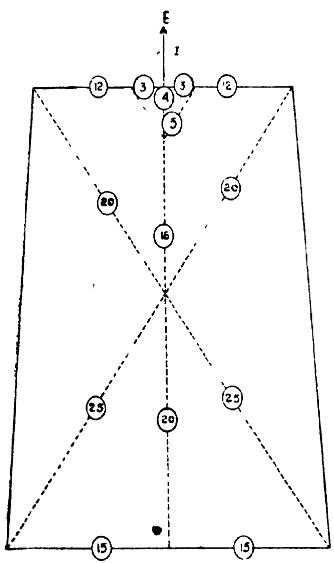
DESCRIBING A CIRCLE
WHOSE CIRCUMFERENCE = PEREMETER OF A SQUARE

DIAGRAM 13

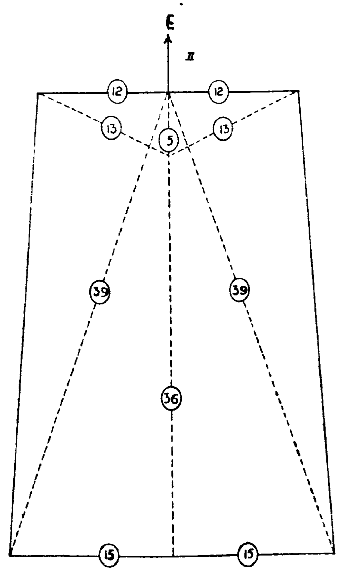
(Page 159)

XV

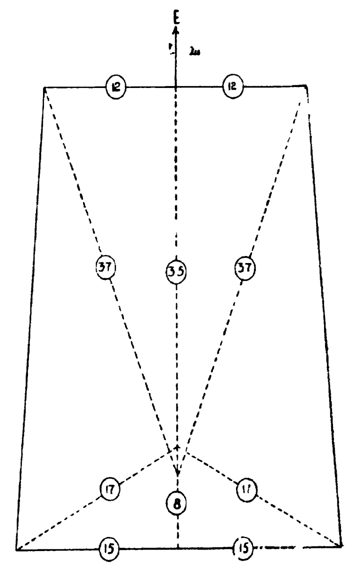
Construction (a)



Construction (b)



Construction (c)

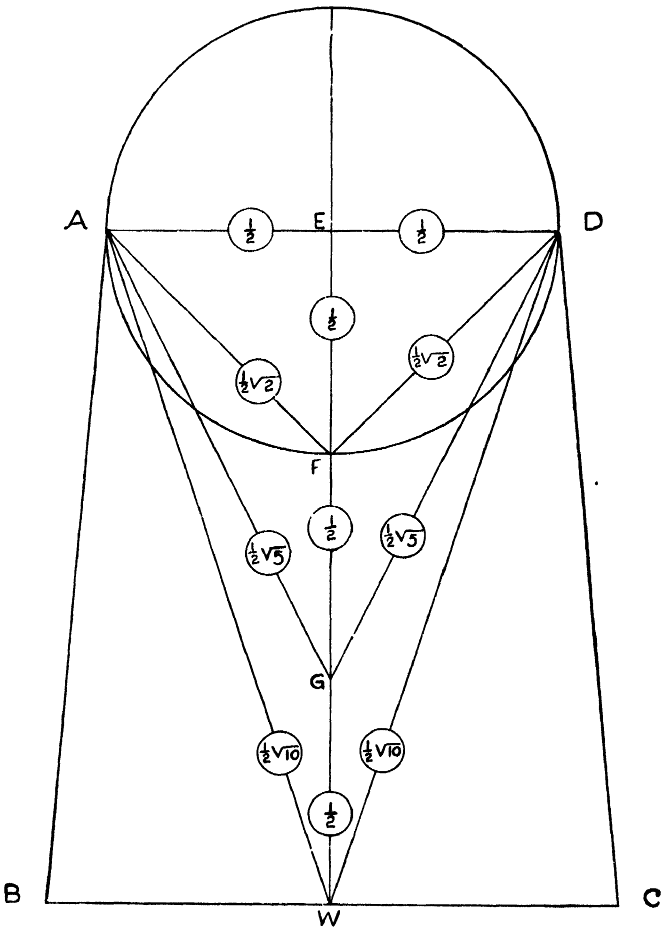


CONSTRUCTION OF MAHAVEDI BY MEANS OF PERFECT SQUARES

DIAGRAM 14

(Page 169)

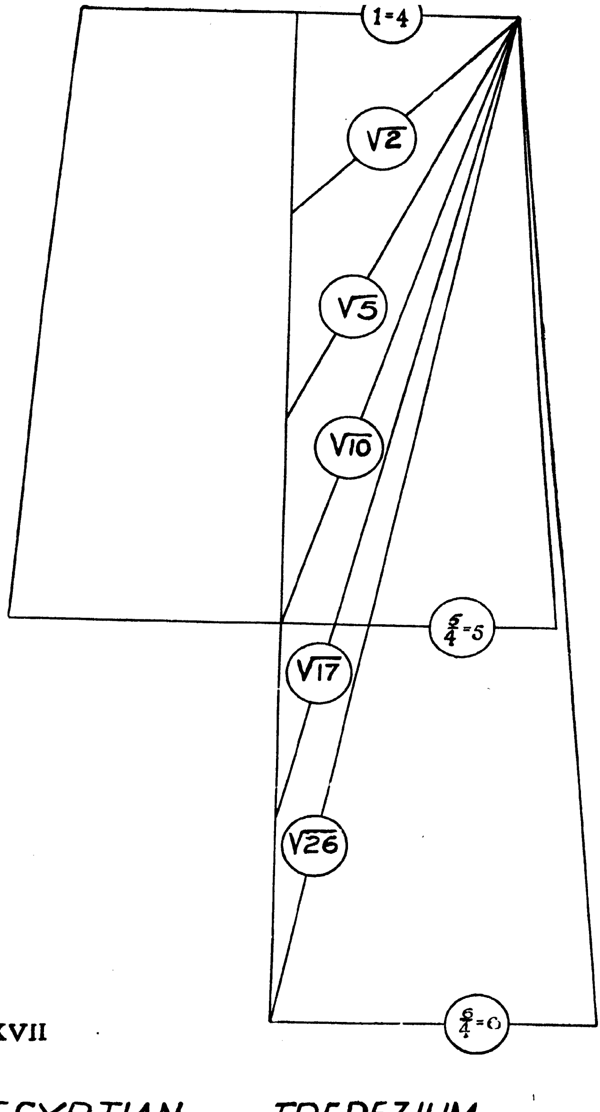
XVI



DERIVATION OF SQUARE ROOTS FROM MAHAVEDI

DIAGRAM 15

(Page 172)



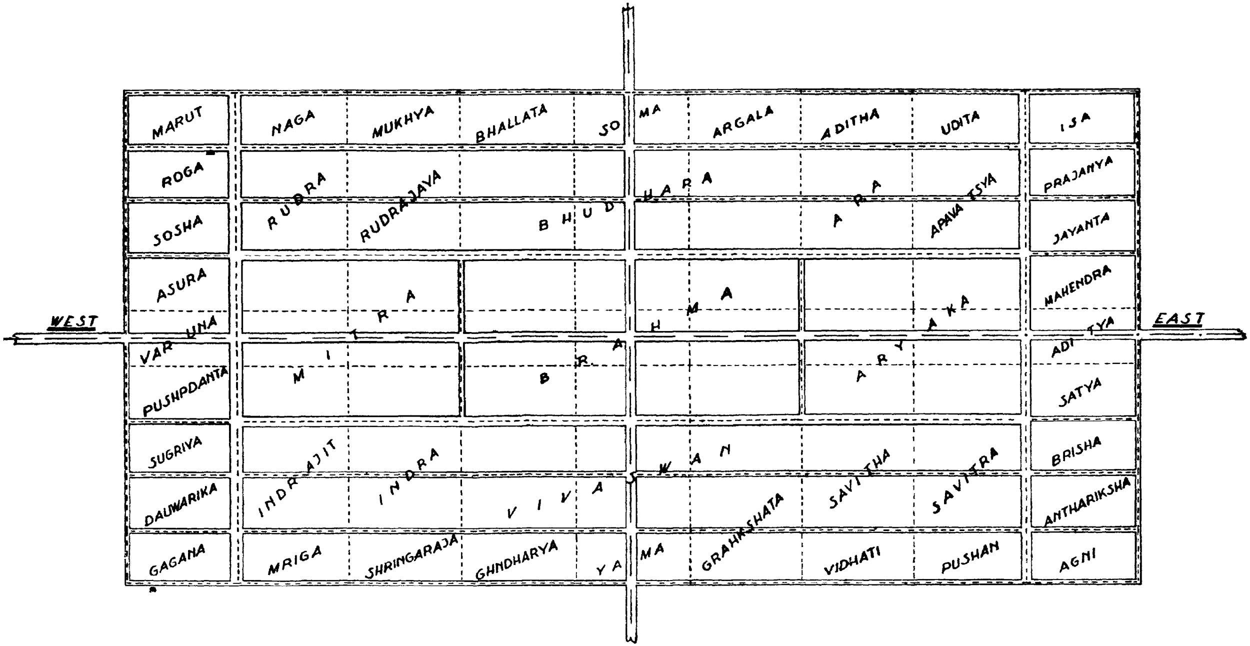
XVII

EGYPTIAN TREPEZIUM

SUPEIMPOSED ON PAITRAKI - VEDI

DIAGRAM 16
(Page 179)

XVIII



DANDAKA LAYOUT

IN PARAMASAYIKA OF 81 DIVISIONS AS SHOWND BY DOTTED LINE

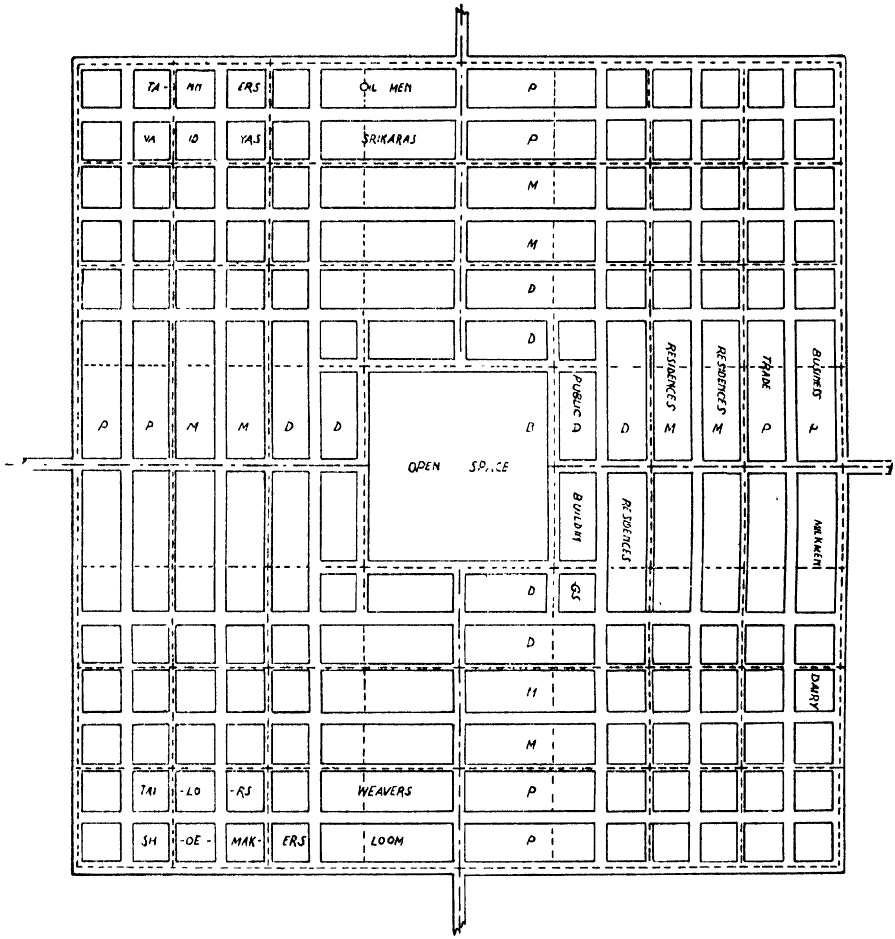
LENGTH= TWICE THE BREADTH

THE NAME OF EACH PLOT IS SHOWN BY THE NAME OF THE GOD IN EACH

DIAGRAM 17

(Page 197)

XIX



SARVATOBHADRA

BY MANDUKA 64 DIVISIONS

P= PAISACHA ROUNDS FOR TRADE & BUSINESS

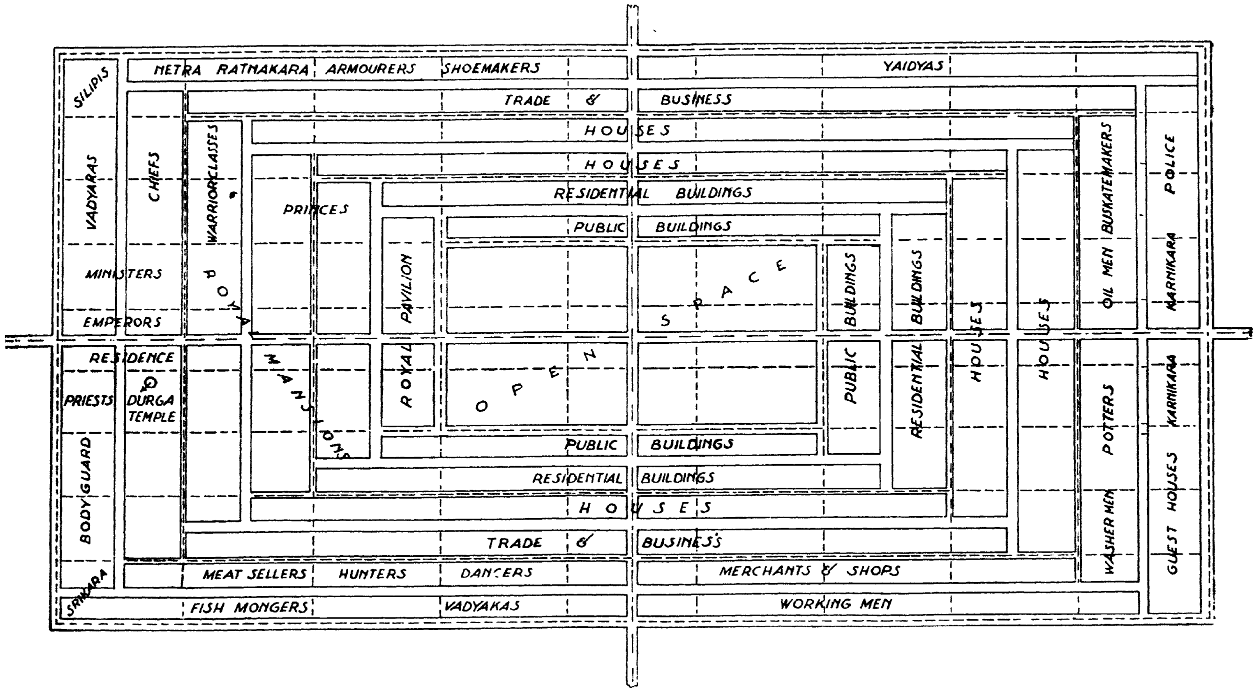
M= MANUSHA " " RESIDENCE

D= DAIVIKA " " RESIDENCES & PUBLIC BUILDINGS

B= BRAHMA " OPEN SPACE

DIAGRAM 18

(See P. 203).



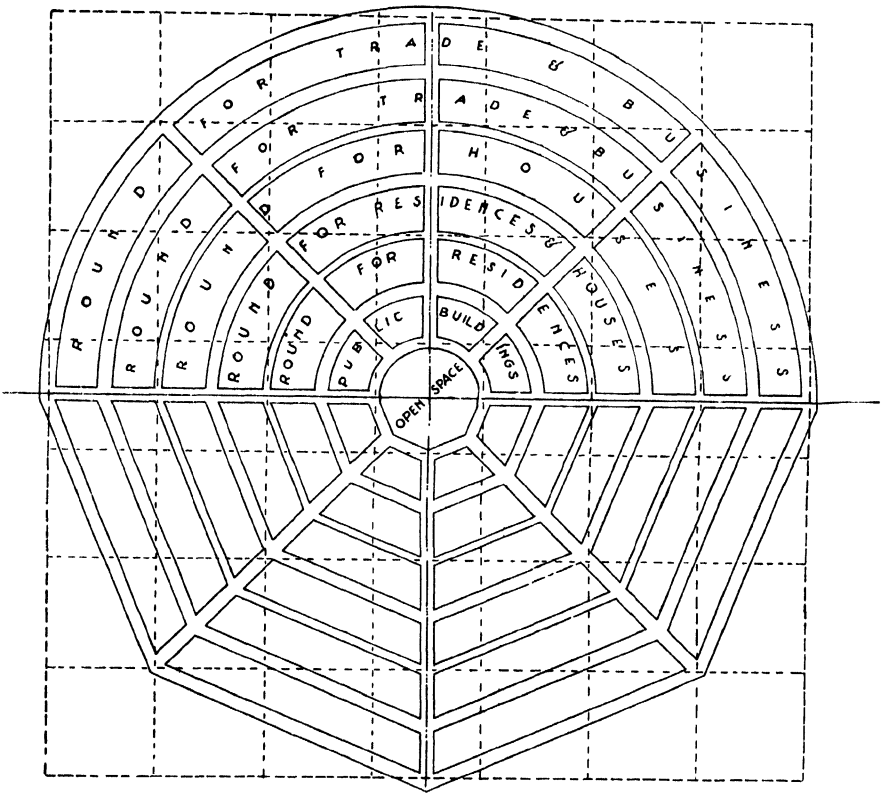
NANDYA-VARTA LAYOUT

IN PARAMASAYIKA OF 81 DIVISIONS

DIAGRAM 19

(See P. 207)

XXI



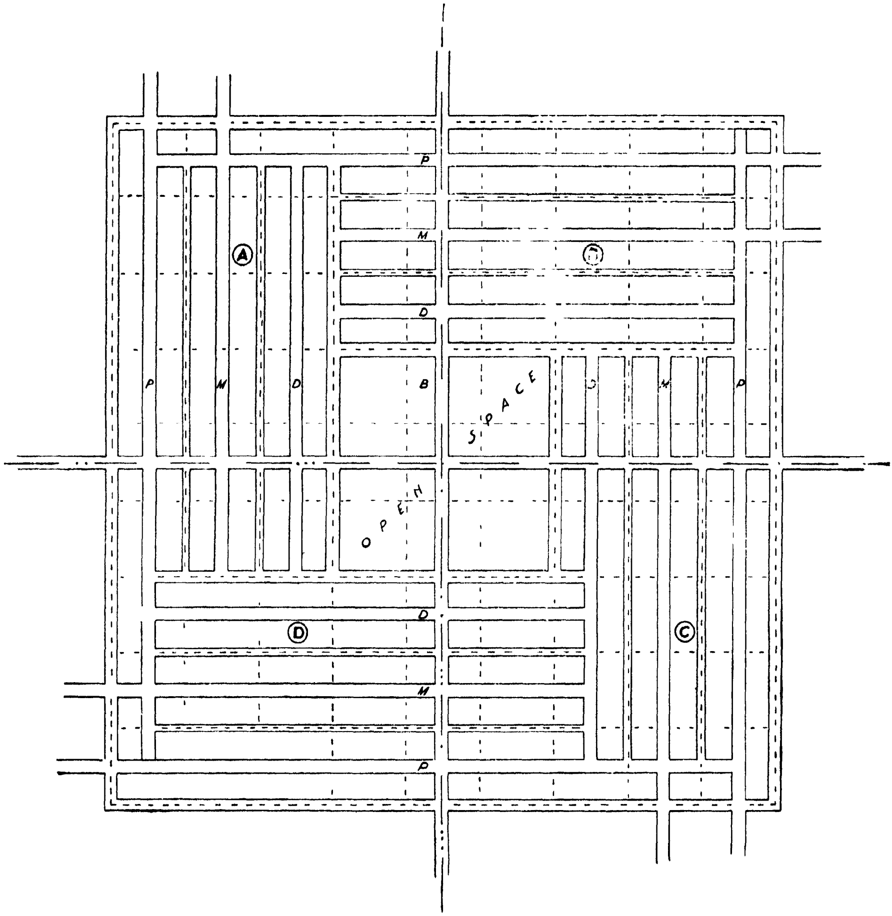
LAYOUT: PADMAKA

IN STANDILA OF 49 DIVISIOS
TOP HALF CIRCULAR LAYOUT
LOWER HALF OCTAGONAL LAYOUT

DIAGRAM 20

(See P. 208).

XXII



SWASTIKA LAYOUT

IN PARAMASAYIKA OF 81 DIVISIONS.

A, B, C, & D, SHOW DIFFERENT ZONES

P= PAISACHA ROUNDS FOR TRADE & BUSINESS

M= MANUSHA .. .. RESIDENCE

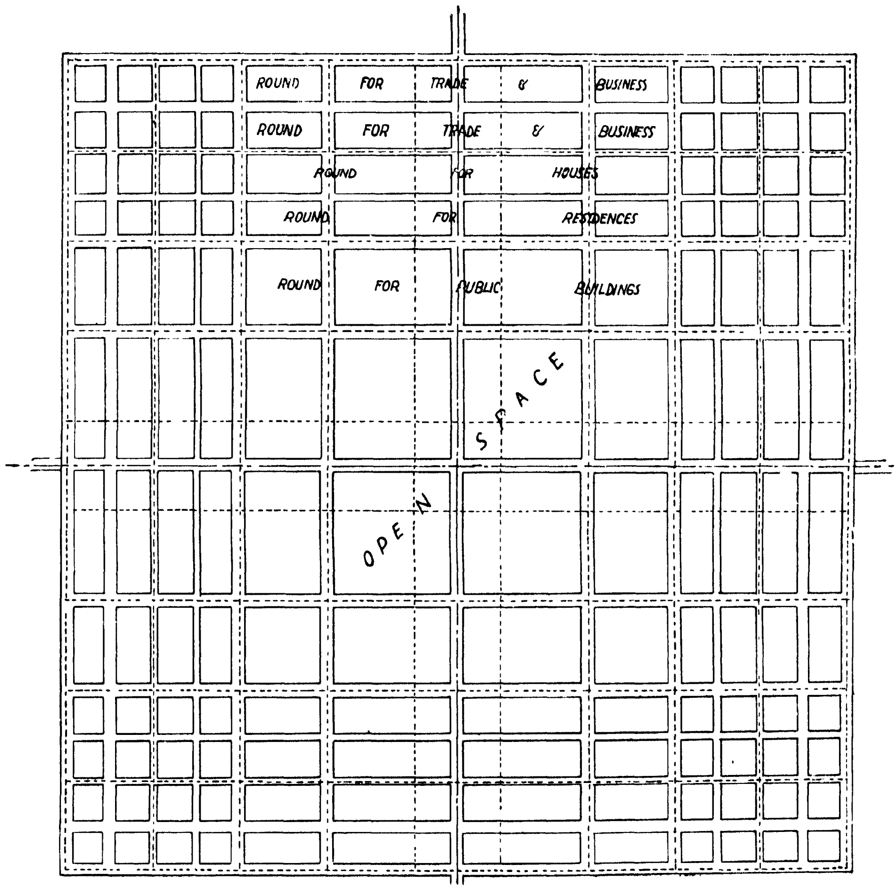
D= DAIVIKA . .. RESIDENCES & PUBLIC BUILDINGS

B= BRAHMA .. .. OPEN SPACE

DIAGRAM 21

(See P. 210).

XXIII

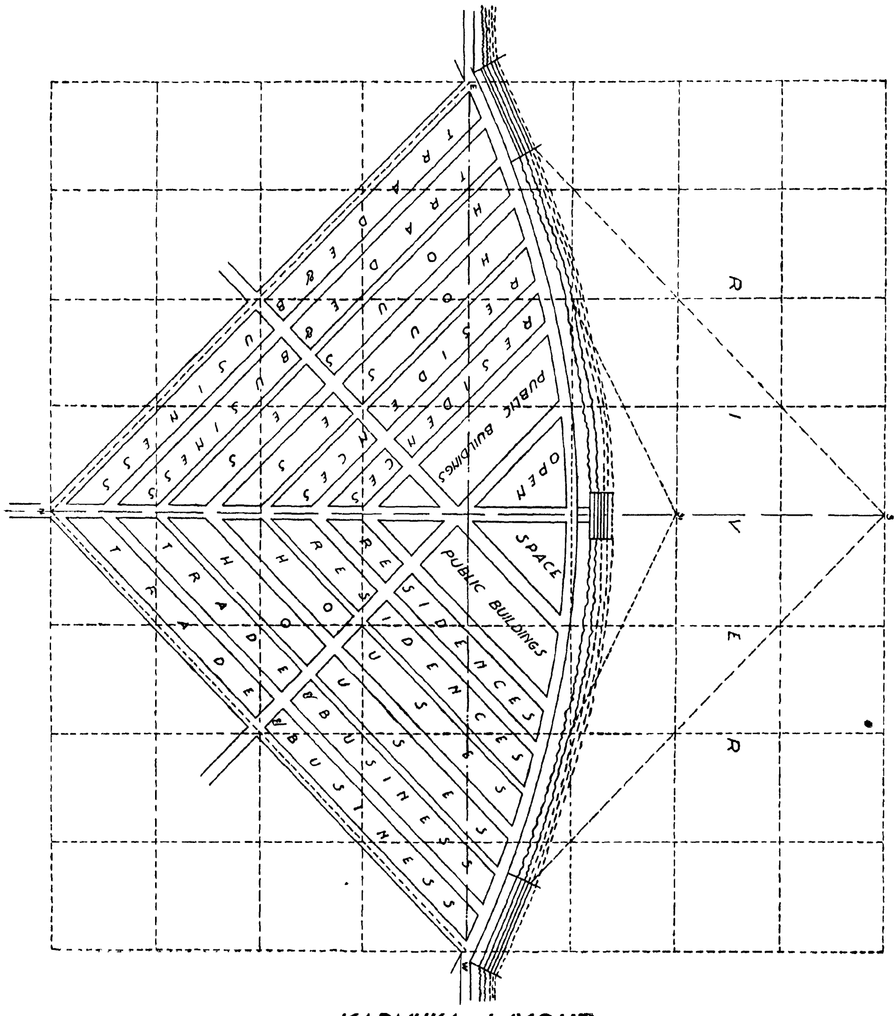


PRASTHARA LAYOUT
IN PARAMASAYIRA OF 81 DIVISIONS
IN PITHA OF 9 DIVISIONS
IN MAHAPITH OF 16 DIVISIONS

DIAGRAM 22

(See P. 212).

XXIV

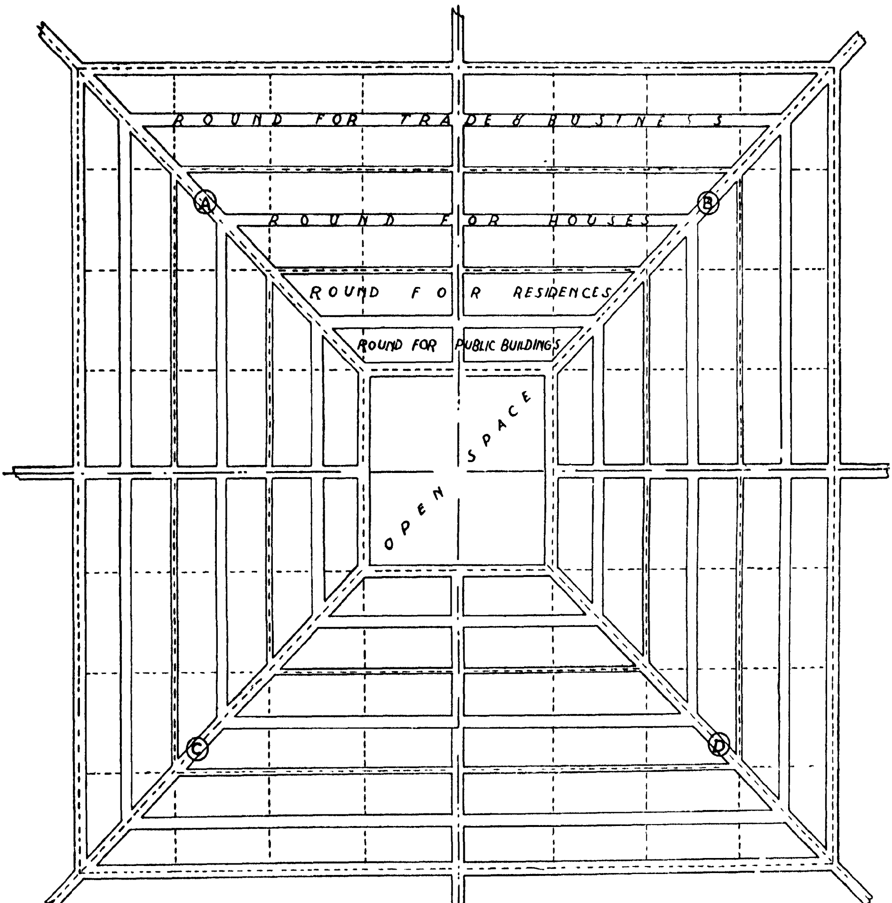


KARMUKA LAYOUT
IN MANDUKA OF 64 DIVISIONS

DIAGRAM 23

(See P. 213).

XXV



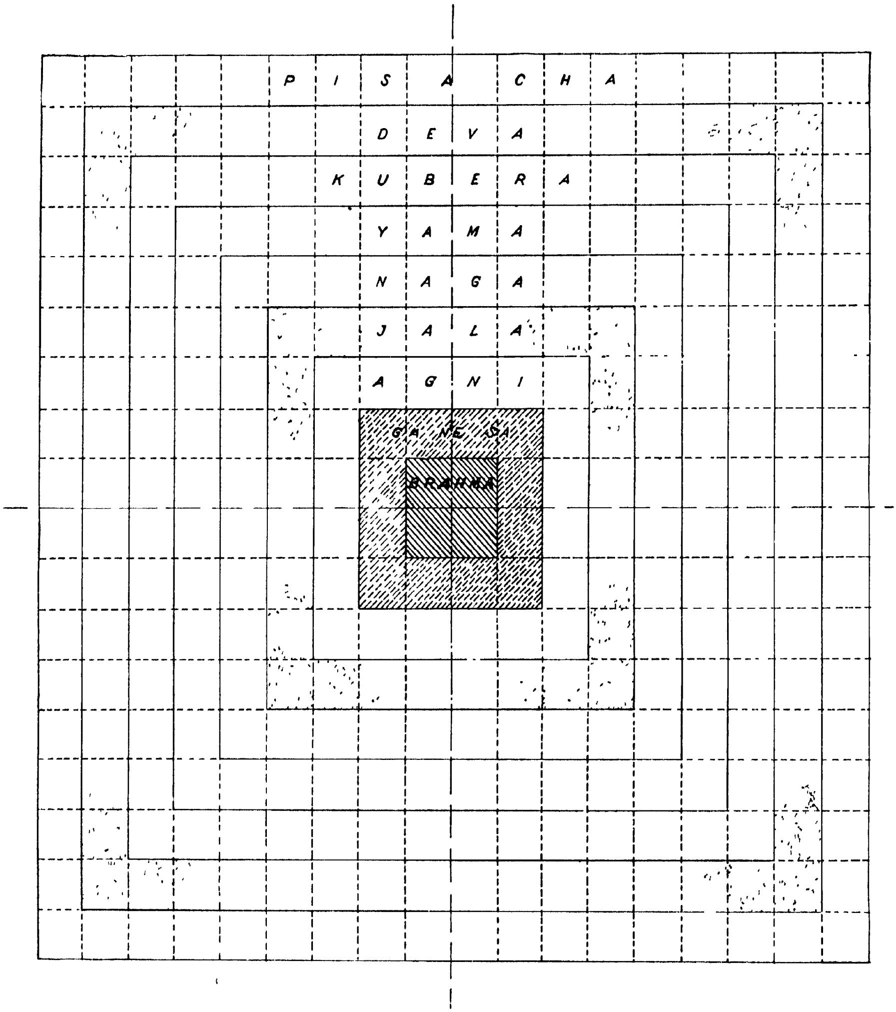
CHATURMUKHA LAYOUT

IN MANDUKA OF 64 DIVISIONS
A, B, C, D, SHOW 4 ZONES

DIAGRAM 24

(See P. 214).

XXVI

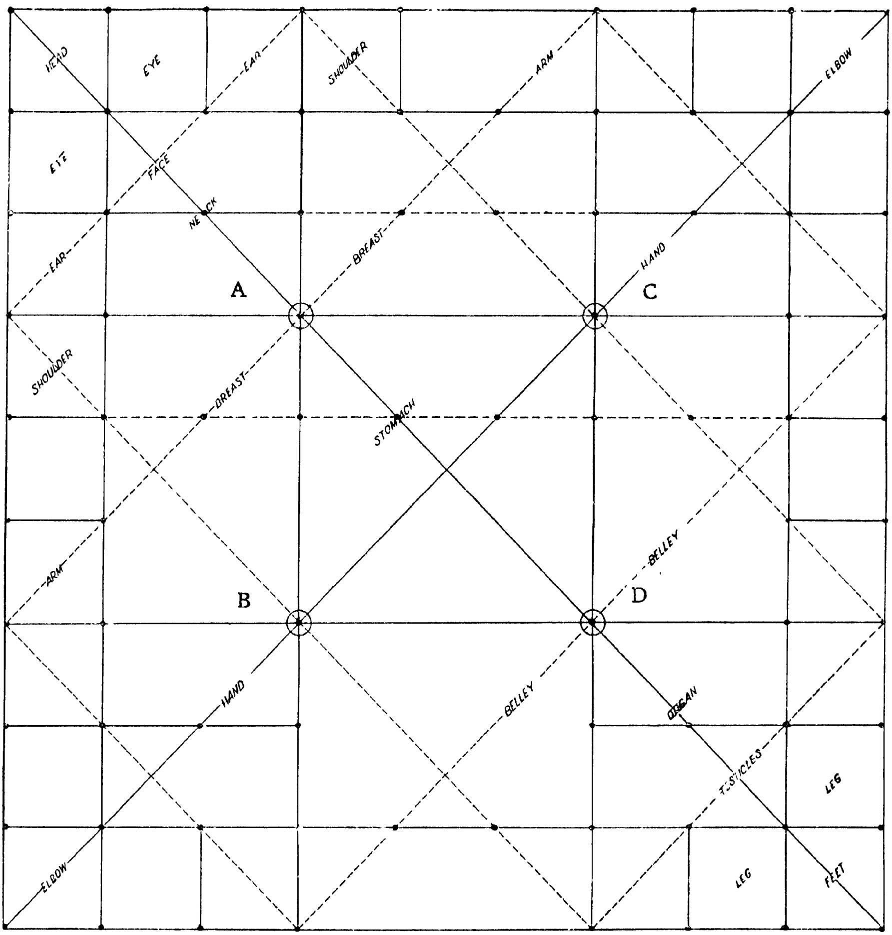


VITHI VIDHANA IN BUILDING CONSTRUCTION

DIAGRAM 25

(See P. 229).

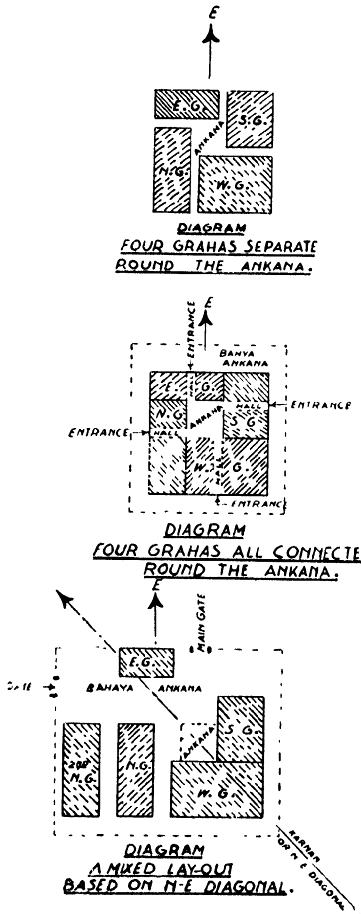
XXVII



VASTU RAKSHASA LYING WITH HIS HEAD - N-E.
MARMAS ARE MARKED.

DIAGRAM 26
(Page 232)

XXVIII

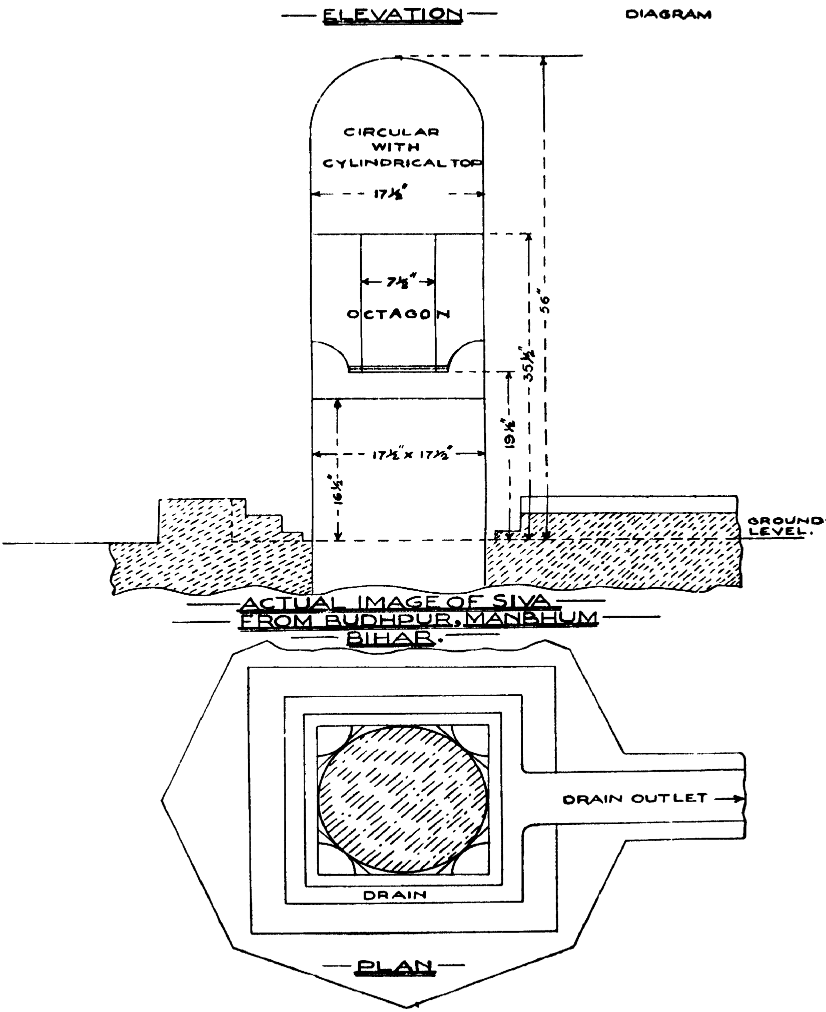


House Block Lay Out

DIAGRAM 27

(Page 240)

XXIX

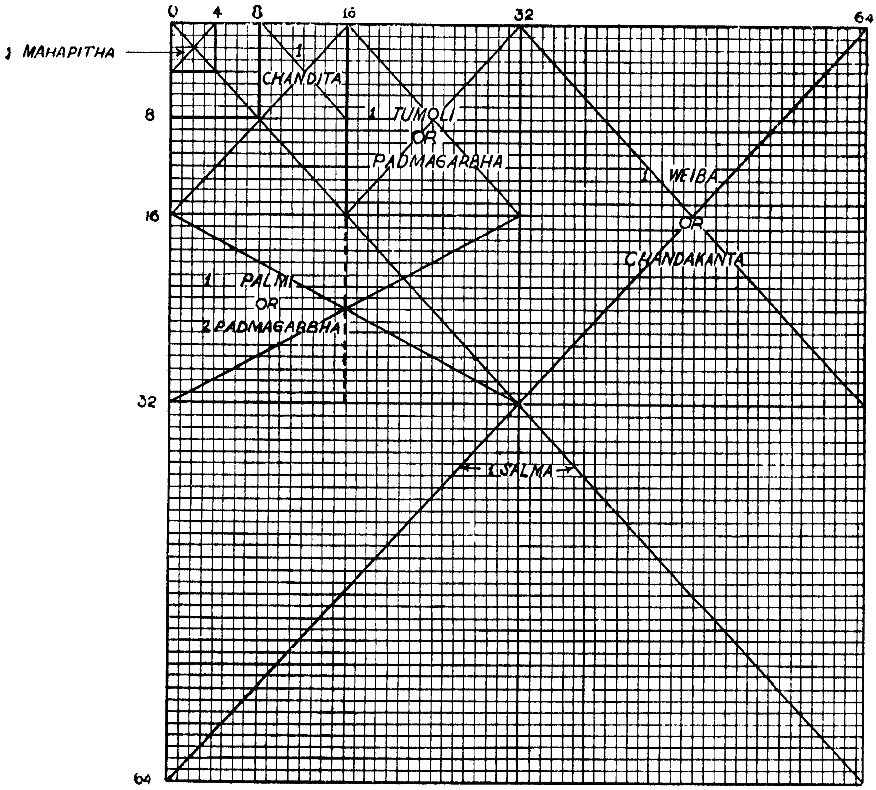


Sivalingam

DIAGRAM 28

(See P. 266).

XXX



MALTESE SURFACE MEASURE

1 SALMA = 4 WEIBA = 8 PALMI = 16 TUMOLI = 16 X 256 CANNE

= 4 X 2 PALMI = 8 X 2 TUMOLI = 16 X 16 X 16 CANNE

DIAGRAM 29

(Page 283)

Maltese Salmá over Hindu Mandalí

XXXI

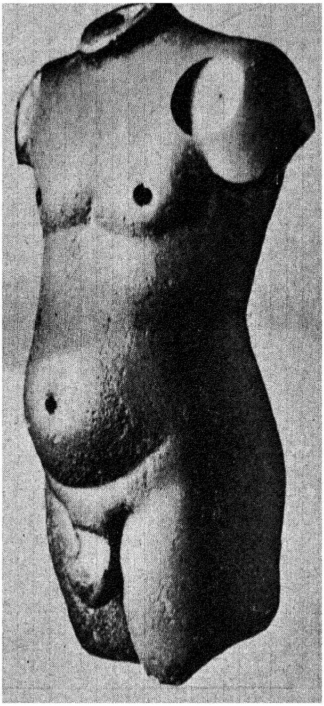


Fig. 1

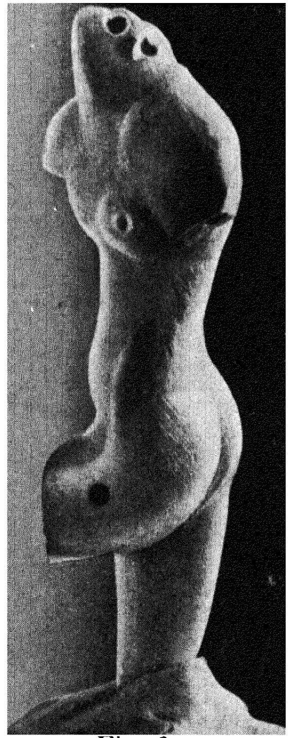


Fig. 2

(See P. 243)

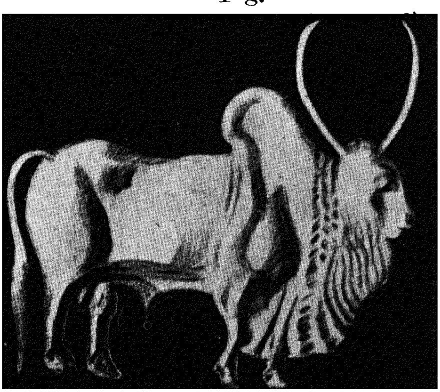


Fig. 3

(See P. 244).

Fig. 1
A Man from Harappa.

Fig. 2
A Dancer from Harappa.

Fig. 3
"The Bull" from Mohenjodaro.

XXXII

Fig. 4 Buddha of Gandhara.

Fig. 5 Buddha of Anuradhapura.

Fig. 6 Buddha of Ajanta.

Fig. 7 Budda of Saranath.

Fig. 4
(See P. 251).

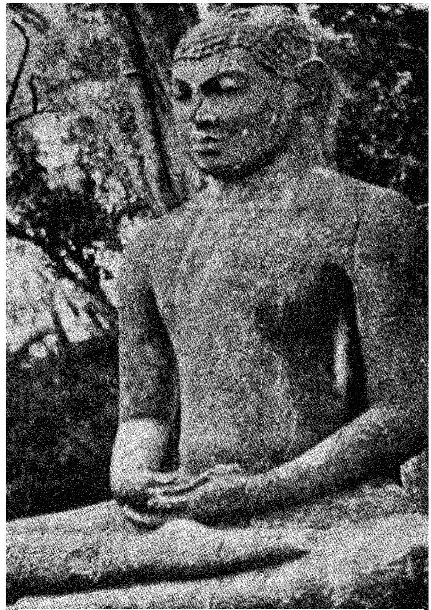


Fig. 5
(See P. 251)

XXXIII

Fig. 8—Bodhisattva from Borobudur.
(See P. 255).

Fig. 9—Durga Slaying Mahishasura from Jav
(See P. 257).

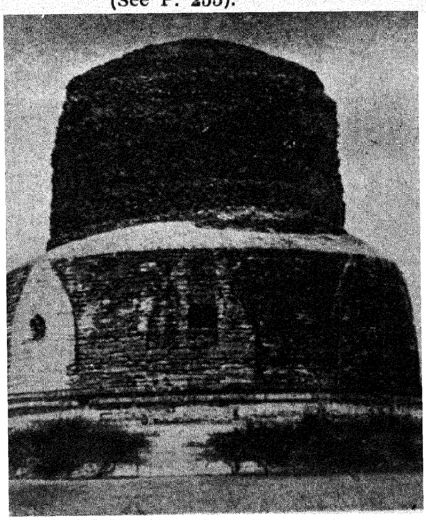


Fig. 10—Stupa of Saranath.

(See P. 259.)

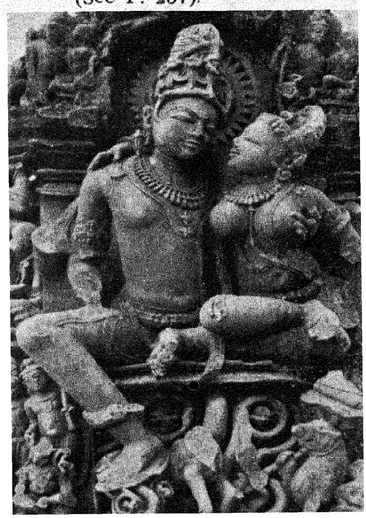


Fig. 12—Shiva and Parvti from Khujraho—
Courtesey : Allahabad Municipal Museum.
(See P. 274).

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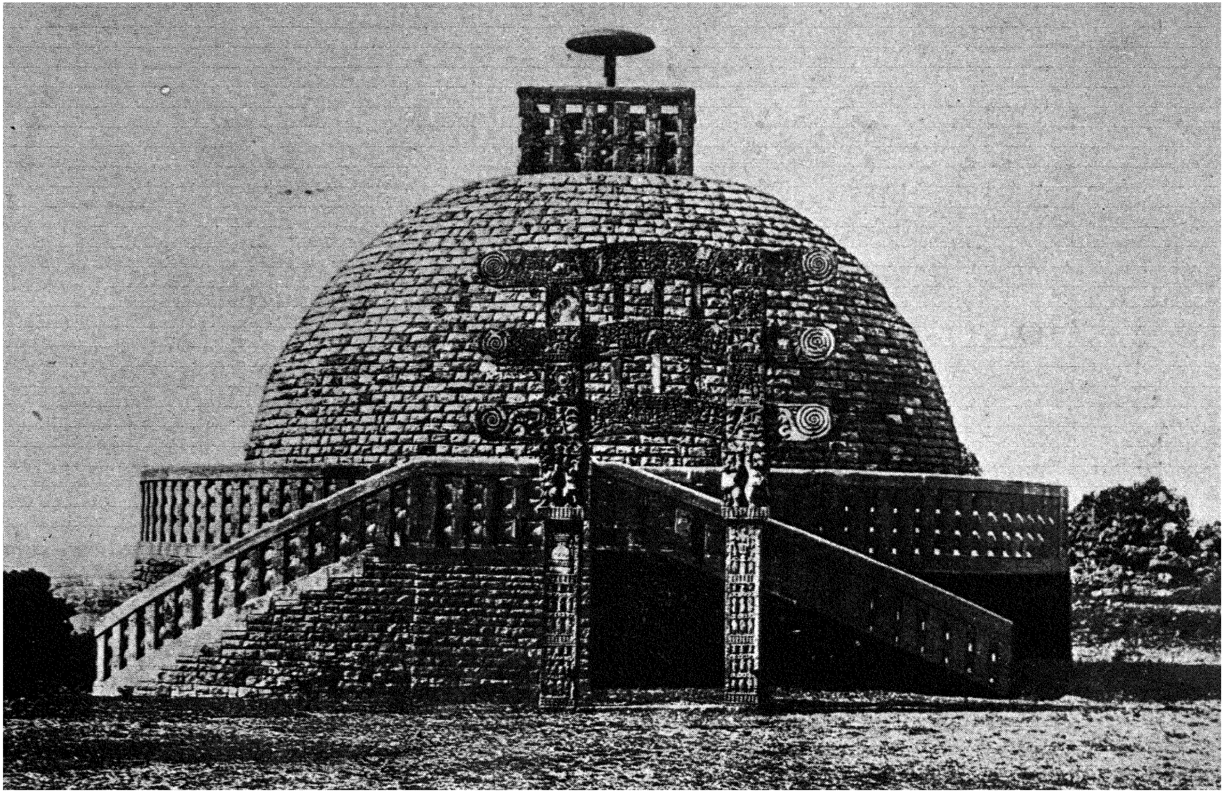

Fig. 11 Stupa No. 3 at Sanchi

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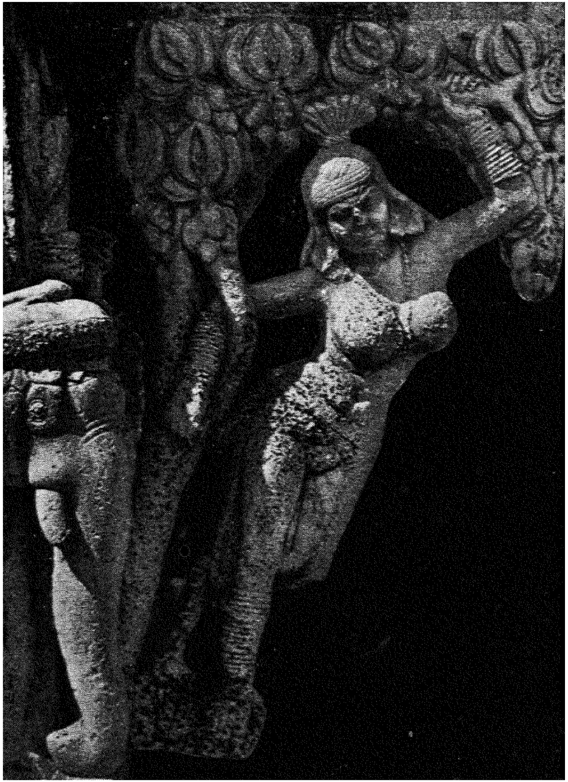
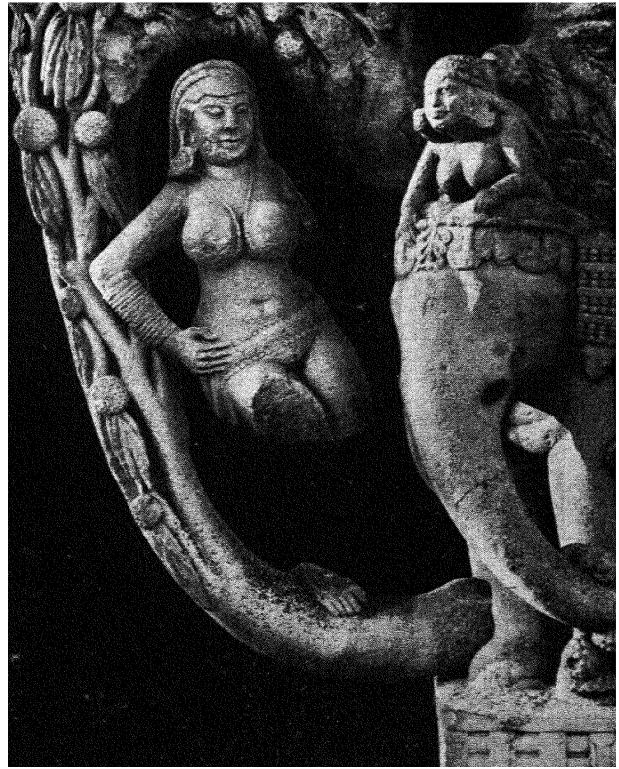


Fig, 13—Yakshi from Eastern Gateway, Stupa 1, Sanchi.
(See P. 268).



Fig, 14—Yakshi from Northern Gateway, Stupa 1, Sanchi.
(See P. 268).

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(C) (A) (B)

Fig. 15 (See P. 270).

Fig. 15

(A) "Queen Bess" from Kausambi.

(B) A Gentleman (Merchant Prince) from Kausambi.

(C) Lady (?) from Bitha.

Fig. 16
"The Prince" from Manbhum.

Fig. 17
Totem Elephant
Village Kunt, Chota Nagpur.

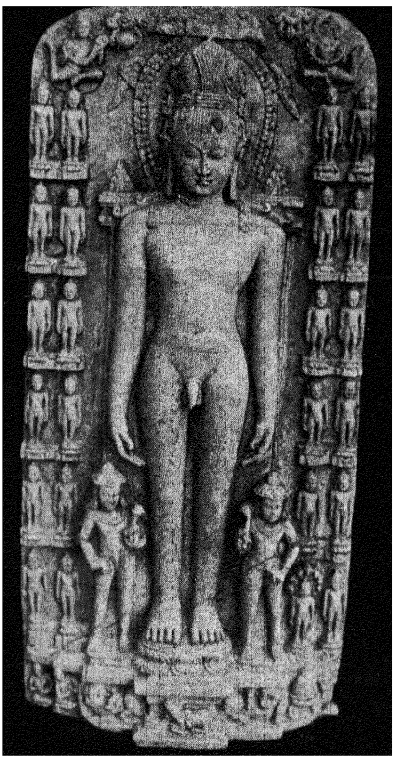

Fig. 16
(See P. 271).

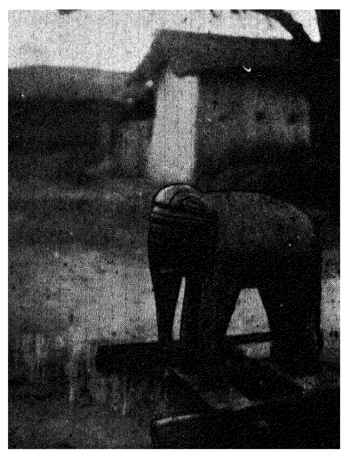

Fig. 17
(See P. 275).

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Fig. 18—" Buddha " of recent origin by a School boy.
Fig. 19—" Sukra Maharshi " in wood by an " Acari " from Travancore

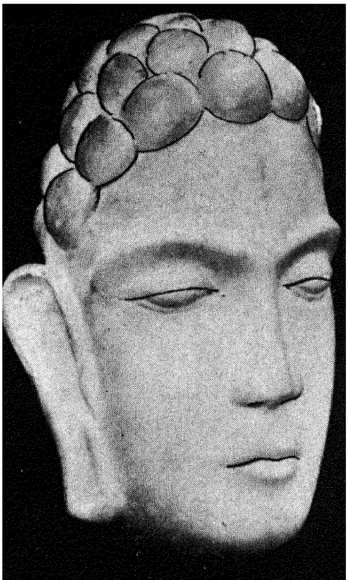

Fig. 18
(See P. 275).

Fig. 19
(See P. 276).

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ERRATA

P. 1	line 6 :	*for*	the Art	*read*	Art
P. 5	„ 12 :	*after*	Thantra-samuchaya	*add*	etc.
P. 45	„ 10 :	*for*	Puran	*read*	Purana
P. 58	„ 1 :	*for*	Panano	*read*	Panam
P. 58	„ 21 :	*for*	rods	*read*	rod
P. 65	„ 8 :	*for*	bear	*read*	bears
P. 66	„ 28 :	*before*	Nakshatra	*omit*	undernoted
P. 83	„ 83 :	*for*	the stick	*read*	but the stick
P. 108	„ 10 :	*for*	division	*read*	divisor
P. 110	„ 13 :	*for*	$\cdot 9$	*read*	$\cdot\dot{9}$
P. 118	„ 7 :	*for*	ind finits	*read*	in definite
P. 119	„ 23 :	*for*	the cclyptic	*read*	any
P. 119	„ 26 :	*for*	Calendei	*read*	Calendar
P. 132	„ 8 :	*for*	deservice	*read*	disservice
P. 141	„ 1 :	*for*	[illegible]	*read*	[illegible]
P. 144	„ 22 :	*for*	3.Ma Mum-Ma	*read*	3 Ma=Mum-Ma
P. 148	„ 24 :	*for*	$\frac{1}{0}$	*read*	$1\frac{1}{0}$
P. 152	„ 10 :	*for*	evaluation	*read*	evaluation of
P. 161	„ 11 :	*for*	extending OB	*read*	extending OE
P. 163	„ 23 :	*for*	Egyptians value	*read*	Egyptian value
P. 187	„ 5 :	*for*	There	*read*	These
P. 200	„ 12 :	*for*	was	*read*	were
P. 204	„ 27 :	*omit*	(at the end of the line) are		
P. 207	„ 27 :	*for*	Numbers	*read*	number
P. 211	„ 6 :	*for*	nre	*read*	are
P. 218	„ 23 :	*for*	big	*read*	beg
P. 254	„ 22 :	*for*	cultures	*read*	culture
P. 269	„ 6 :	*add*	2, 3 5	*before*	7, 8, 9
P. 301	„ bottom of p :	*for*	A′, A′, A′	*read*	A′, A, A″

Tear off this page after making corrections in the text.